Urban Forestry in the Great Plains – An Annotated Bibliography on Current Topics

Hugh Ellerman
Raina Engelhard
Jake Essink
Carlee Koehler
Cody Jones
Sienna Franks
Sam Feilmeier
Wyatt Koehler
Jahid Muhammad
Roberto Nayituriki
Katie Pace
Brianna Sorgen
Steven Spotanski
Jayme Trainer

Advisor:
Dr. Lord Ameyaw
University of Nebraska-Lincoln

Introduction

This document is a comprehensive list of citations and annotations of works including books, articles, documents, and websites meant to offer readers a single location to find information on research regarding urban forests in the North American Midwest. The Midwest in this list is considered to consist of the following states: Montana, North Dakota, South Dakota, Wyoming, Nebraska, Colorado, Kansas, New Mexico, Oklahoma, and Texas. There are four topics in this annotated bibliography - Pests and Diseases of Urban Forests; Urban Tree Monitoring; Urban Forests, the Environment, and Climate Change; and Value of Urban Forests. Each topic is further broken down into themes for more specific discussion. Most sources listed here may refer directly and exclusively to the Midwest, while additional sources on the list may apply to forests more broadly. This document is a combination of work submitted by students in University of Nebraska-Lincoln's course HORT 457/857: Greenspace and Urban Forestry Management to fulfil the term project requirements of the course.

Readers will be informed of the relevancy and quality of sources listed in this document as well as where gaps are in information. Annotations include a summary of the main points and themes of the resource, an assessment of author credibility and potential bias, and a reflection by authors of this document. A flowchart is provided for a visual flow of author concepts. Goals of this project are to trace the history of urban forestry ideas through literature and organize and analyze original contributing authors for mass scientific consumption. References are cited in APA format.

Topic 1: Pests and Diseases of Urban Forests in the North American Midwest

Theme 1: Species diversity

Theme 2: Resilience

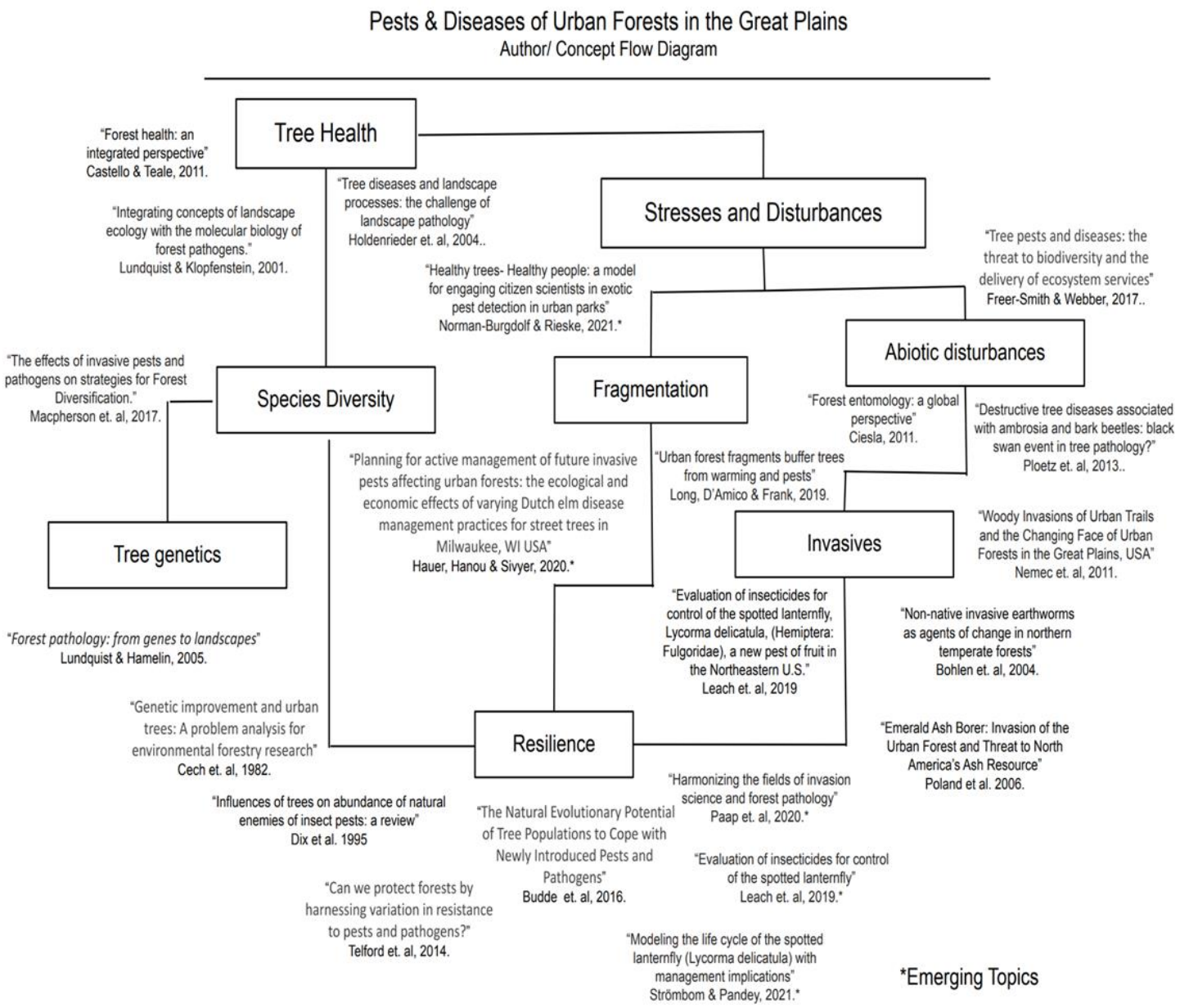
Theme 3: Biotic/abiotic stresses and or disturbances

Theme 4: Tree genetics

Theme 5: Associated challenges

Theme 6: Emerging topics

Flowchart: Pests and Diseases of Urban Forests in the North American Midwest



Bohlen, P. J., Scheu, S., Hale, C. M., McLean, M. A., Migge, S., Groffman, P. M., & Parkinson, D. (2004). Non-native invasive earthworms as agents of change in northern temperate forests. *Frontiers in Ecology and the Environment*, *2*(8), 427–435.

This study is a nine-page peer reviewed article examining the effect of invasive earthworms on carbon and nitrogen cycling, soil food webs, soil structure, and vulnerability to other invasive species in northern temperate urban forests. This source is credible as it was published in the Ecological Society of America, Frontiers in ecology and the environment. This study adds onto the knowledge base of urban forest soil composition and causes of vulnerability of these forests to invasive species.

Budde, Nielsen, L. R., Ravn, H. P., & Kjær, E. D. (2016). The Natural Evolutionary Potential of Tree Populations to Cope with Newly Introduced Pests and Pathogens—Lessons Learned From Forest Health Catastrophes in Recent Decades. Current Forestry Reports, 2(1), 18–29. https://doi.org/10.1007/s40725-016-0029-9

This source is a 12-page, peer reviewed scientific article, published in the Current Forestry Reports. This article focuses on the causes, consequences, and resilience of native species when exotic pests and pathogens are introduced. Through these observations, the authors studied the effect of natural evolution of native tree species to cope with these introduced exotic species. The authors suggest that breeding programs of surviving/resistant native trees should be completed on a large scale and avoid uniformity of genetics, and that a greater focus should be placed on the identification, protection, and breeding of surviving tree specimens. The authors of this source and the source are credible, as the authors are

employees and members of the University of Copenhagen and the article was published in the journal of Current Forestry Reports. This article builds on previous knowledge of the effects of invasive species on native tree species and aims to inform more efficient management practices.

Castello, J. D., & Teale, S. A. (Eds.). (2011). *Forest health: an integrated perspective*. Cambridge University Press.

Forest health: an integrated perspective is an 11-chapter, 385-page textbook defining an ecological conceptual framework that unifies sub-disciplines of forest health and protection. Topics covered include forest health and mortality, ecological components of forests, and human dimensions applied in all forest types. Authors are credible considering the extensive list of contributors spanning universities and the USDA Forest Service. This book is a thoughtful, full-encompassing approach to forest health and how to measure such. It adds to previous knowledge on forest health in temperate forests among others and even offers online-accessible original datasets used for case studies reviewed within the text.

Cech, F. C., Collins, W. H., Flemer, W., Gabriel, W. J., Gerhold, H. D., Karnosky, D., Little, S., Orton, E. R., Santamour, F. S., Steiner, K., Townsend, A. M., Valentine, F. A., & Westfall, R. T. (1982). *Genetic improvement and urban trees: A problem analysis for environmental forestry research*. *Hathi Trust*. The Group. Retrieved April 19, 2022, from https://catalog.hathitrust.org/Record/007397019/Home.

Cech et. al consider a problem analysis for environmental forestry research which can be located in The University of Minnesota library. This study was published in 1982. While the whole catalog is a very useful tool, the main subject of focus starts on page 23,

Resistance to Diseases, Insects, Air Pollution. The article of focus discusses the pros and cons of breeding and planting trees for pest and disease resistance. It showcased previous successes with certain trees and also discusses failures which helps researchers to understand that breeding for resistance can work, but not for all trees. This is a credible source because the authors work with the Consortium for Environmental Forestry Studies and was supported by the USDA Forest Service.

Ciesla, W. (2011). *Forest entomology: a global perspective*. John Wiley & Sons.

This source is a 15-chapter, 400-page textbook examining forest insects in a global context, emphasizing the species of major concern. The main point of the text is to provide descriptions of important forest insects and their histories and impacts. The book is organized in chapters correlating with damage caused by insects rather than taxonomic groups. The beginning of the text also broadly examines the role of insects in forests on their effects and coincidental management approaches. The author is credible due to his profession as a forest health specialist, extensive publications, and 2005 recipient of the Western Forest Insect Work Conference, Founder's Award. This source consolidates numerous studies on entomology and forestry globally and contributes to the field by providing solutions and recommendations on how to recognize and manage insects in forest settings.

Dix, M.E., Johnson, R.J., Harrell, M.O. *et al.* Influences of trees on abundance of natural enemies of insect pests: a review. *Agroforest Syst* 29, 303–311 (1995). https://doi.org/10.1007/BF00704876

The topics covered in this article are agricultural pests, natural enemies of pests, conservation, and field edges. The main idea of the article is sustaining habitat including

forests along crop edges to conserve and sustain natural enemies of crop pests for natural pest control as an alternative to pesticides. The authors of this study are credible because they are professionals at the USDA Agroforestry and professors/ researchers in Departments of Forestry, Horticulture and Entomology at a university level. This study is consistent with existing literature on utilizing natural predators of crop pests as an alternative to pesticides.

Freer-Smith, P.H., Webber, J.F. (2017). Tree pests and diseases: the threat to biodiversity and the delivery of ecosystem services. *Biodivers Conserv* 26, 3167–3181.

This source is a 13-page peer-reviewed scientific article published in 2015. This article looks at the increasing number of invasive pests and diseases and how the threat they pose is increasing alongside climate change and globalization. The information in this article is prevalent in the Midwest because the relationship between the risk that comes from invasive organisms and biological diversity is an extremely important issue in present forest strategies. The data given in the article shows a demonstration of the scale and potential of the level of damage that is being caused by pests and diseases. The study also discusses the analysis of the ecosystem services and identification of the benefits and helps guide strategies on tree health and cost for plant health and outbreak management.

Hauer, Hanou, I. S., & Sivyer, D. (2020). Planning for active management of future invasive pests affecting urban forests: the ecological and economic effects of varying Dutch elm disease management practices for street trees in Milwaukee, WI USA. Urban Ecosystems, 23(5), 1005–1022. https://doi.org/10.1007/s11252-020-00976-6

This source is a 37-page peer-reviewed scientific article, published in 2020. This article is prevalent to the Great Plains as Dutch elm disease is rapidly moving west throughout the

country. The knowledge of this article will help further education on the management of serious pests and diseases. This study examines the effect Dutch elm disease has had on over 100,00 American elm trees *(Ulmus americana L.)* located in Milwaukee, Wisconsin. This article offers strategies to manage other serious pests and diseases like the Emerald Ash Borer that contribute to significant damage to the urban tree population. The study found that Dutch elm disease that was left alone resulted in loss ecologically and economically. However, research showed that through Best Management Practices (BMP) that used methods that were designed to reduce the frequency of Dutch elm disease led to a significant reduction in tree mortality. This is a credible source as its authors have their PH. D in urban forestry and are employed by the University of Wisconsin.

Holdenrieder, O., Pautasso, M., Weisberg, P. J., & Lonsdale, D. (2004). Tree diseases and landscape processes: the challenge of landscape pathology. *Trends in Ecology & Evolution*, *19*(8), 446-452.

This article is published in the Elsevier journal of Trends in Ecology and Evolution and focuses on laying the groundwork and explaining the use of landscape pathology to observe invasive pests and pathogens and how it should influence management. The authors also state that Forest Pathology must collaborate more closely with other emerging disciplines if management practices based on forest pathology are to succeed. This source is credible as they are members and employees of the Federal Institute of Technology, Zurich, the University of Sheffield, and the University of Nevada. This article gives an introductory overview of landscape pathology and its role in examining and managing alien pests and pathogens.

Leach, H., Biddinger, D. J., Krawczyk, G., Smyers, E., & Urban, J. M. (2019). Evaluation of insecticides for control of the spotted lanternfly, Lycorma delicatula, (Hemiptera: Fulgoridae), a new pest of fruit in the Northeastern U.S. *Crop Protection*, *124*, 104833. https://doi.org/10.1016/j.cropro.2019.05.027

This peer reviewed scientific article, published in the Elsevier journal of Crop Protection, which examines the effectiveness of various insecticides to control the spotted lanternfly. Of the insecticides tested, only thiamethoxam and bifenthrin offered control of 50% or greater up to 14 days after application. This study makes it clear that chemical control of spotted lanternfly is the only reliable form of control until biological or cultural control measures are developed. This source is credible as the research was completed by members of the Pennsylvania State University and published in the Elsevier scientific journal.

Long, L. C., D'Amico, V., & Frank, S. D. (2019). Urban forest fragments buffer trees from warming and pests. *Science of the Total Environment*, *658*, 1523-1530.

Long, D'Amico and Frank researched the effects which urban forests fragments have on buffering individual trees from warming and pests. The main research focus of this article are the differences in temperature, water stress, and M. tenebricosa (a natural enemy variation) density between landscape trees, fragment edge trees, and fragment interior trees. The research found that urban forest fragments showed the greatest benefits of cooling, water loss, and pest resilience while landscape trees showed the least benefits. This source is credible as the authors are employees of the North Carolina State University and the U.S. Forest Service. This article builds on knowledge of the benefits of urban forest fragments compared to urban forest landscape trees. The author recommends the focus of preserving urban forest fragments and planting trees in large clusters rather than single, isolated trees.

Lundquist, J.E., Hamelin, R.C. (2005). *Forest pathology: from genes to landscapes*. The American Phytopathological Society.

This source is a compilation of papers based on the 1999 Montreal American Phytopathological Society Annual Convention that have been published together in a book. Main themes throughout the papers are the integration of molecular biology/ genetics used in taxonomic plant pathology and spatial ecology used in conservation forestry. Papers address use of concepts and methods from epidemiology, spatial ecology, molecular biology and molecular genetics in forest pathology. The authors are credible professionals in their fields that present their developing research. Arguments to continue fusion of genetics and spatial ecology are convincing to make tighter connections within the field of forest pathology.

Lundquist, J. E., & Klopfenstein, N. B. (2001). Integrating concepts of landscape ecology with the molecular biology of forest pathogens. *Forest Ecology and Management*, *150*(3), 213-222.

This source is a 10-page, peer reviewed scientific article, published in the Elsevier journal of Forest Ecology and Management. This article focuses on integrating landscape ecology concepts with molecular biology to describe and examine forest pathogens effects on forest ecology. Understanding the dynamics of forest/landscape ecology and their interaction of forest pathogens will allow for a conceptual link between the two and will influence more efficient management practices. This source is credible as the authors are employees of the USDA Forest Services, and this is published within the Elsevier journal of Forest Ecology and Management. This Article builds on previous knowledge of forest pathogens and forest ecology and presents a new conceptual way to picture the interactions between them.

Macpherson, M. F., Kleczkowski, A., Healey, J. R., Quine, C. P., & Hanley, N. (2017). The effects of invasive pests and pathogens on strategies for Forest Diversification. *Ecological Modeling*, *350*, 87–99. https://doi.org/10.1016/j.ecolmodel.2017.02.003

This source is a peer reviewed scientific article, published in the Elsevier journal of Ecological Modeling. This article focuses on building a novel approach to assess the effect of tree disease on optimal planting strategies to increase tree species diversification. A key result of this study was the discovery that optimal planting proportions are altered with the risk and damage from diseases. The authors state that when a manager is able to plant all tree options, the proportion must be dependent on the probability of pathogen outbreak and the effects of the pathogen on the susceptible tree species. This article is credible as the authors are members and employees of the University of Stirling, Bangor University, Northern Forest Research Station, and the University of St. Andrews. This study uses bioeconomic models to create a novel approach to assess the effect of tree diseases on forest diversification.

Nemec, K. T., Allen, C. R., Alai, A., Clements, G., Kessler, A. C., Kinsell, T., Major, A., & Stephen, B. J. (2011). Woody Invasions of Urban Trails and the Changing Face of Urban Forests in the Great Plains, USA. *The American Midland Naturalist*, *165*(2), 241–256. https://doi.org/10.1674/0003-0031-165.2.241

This article, published by the University of Notre Dame, examines the effects of corridors in the urban forests, such as roads and trails. These corridors provide favorable growing conditions for non-native invasive plant species. The authors of this source are credible as they are members of the Nebraska Cooperative Fish and Wildlife Research Unit and other members of the School of Natural Resources at the University of Nebraska Lincoln. This

study adds on previous urban forest corridor knowledge, as well as provides the first study on the effect of bike trail corridors in the urban forest.

Norman-Burgdolf, & Rieske, L. K. (2021). Healthy trees – Healthy people: A model for engaging citizen scientists in exotic pest detection in urban parks. Urban Forestry & Urban Greening, 60, 127067–. https://doi.org/10.1016/j.ufug.2021.127067

This source is an eight-page peer reviewed scientific article, published in the Elsevier journal of Urban Forestry & Urban Greening. This study was designed to create a pilot program to increase the public's knowledge, awareness and ability to identify invasive tree pests and proper management practices within urban forests. This source is credible as its authors are employees of the University of Kentucky and the article was published in the Elsevier journal of Urban Forestry & Urban Greening.

Paap, T., Wingfield, M. J., Burgess, T. I., Hulbert, J. M., & Santini, A. (2020). Harmonizing the fields of invasion science and forest pathology. *NeoBiota*, *62*, 301.

This study is a peer reviewed scientific article, published in the Pensoft Publisher journal NeoBiota. This study focuses on determining whether or not new technologies are efficiently filling the gap in knowledge between forest pathology and invasive science and examine the benefits of linking these two more closely together. The authors of this article are credible as they are members and employees of the University of Pretoria, Murdoch University, Washington State University, and the Institute for Sustainable Plant Protection. This study provides new knowledge and management practices of combining forest pathology and invasive sciences.

Ploetz, R. C., Hulcr, J., Wingfield, M. J., & De Beer, Z. W. (2013). Destructive tree diseases associated with ambrosia and bark beetles: black swan events in tree pathology?. *Plant disease*, *97*(7), 856-872.

This source is a 17-page, peer reviewed scientific article, published in the American Phytopathological Society Journal of Plant Disease. This article presents a number of destructive diseases associated with ambrosia and bark beetles as a “Black Swan Event”, classified under the black swan event theory. This theory describes a “Black Swan Event” as an unexpected event which is of a large magnitude and consequence. Through reviewing the history of destructive tree diseases associated with ambrosia and bark beetles, they found a multitude of disease outbreaks that can be classified as black swan events. They also found that the frequency of black swan events have increased in the past forty years. This source is credible as the authors are employees of the University of Florida, USDA Forest Service, and University of Pretoria. This study compiles historical knowledge of the destructive tree diseases associated with ambrosia and bark beetles, and categorizes the magnitude and consequences of historical outbreaks.

Poland, Therese M.; McCullough, Deborah G. 2006. Emerald Ash Borer: Invasion of the Urban Forest and the Threat to North America"s Ash Resource. Journal of Forestry: April-May, 2006: 118-124

This peer reviewed article was published in 2006 in the Journal of Forestry. This study summarizes the biology, detection and distribution, ecological and economic impacts, containment strategies, and the restoration and future outlook of the Emerald Ash Borer on urban forests. This source is credible as the authors are employees of the USDA Forest

Service and Michigan State University, and the article was published in the Journal of Forestry. This article compiles the general knowledge of EAB up to 2006.

Strömbom, D., & Pandey, S. (2021). Modeling the life cycle of the spotted lanternfly (Lycorma delicatula) with management implications. *Mathematical Biosciences*, *340*, 108670. https://doi.org/10.1016/j.mbs.2021.108670

This source examines the population growth and varying control measures to combat the invasive species, spotted lanternfly. This article compares six different control measures to control the population of spotted lanternfly and found only three of the six had the potential to be effective. However, they found that even when using the three effective control measures, thirty five percent of the individual population must be found and treated to be effective. This study adds to the relatively small knowledge base, surrounding the emerging invasive species, spotted lanternfly. This is a credible source as its authors are employees of Lafayette College and the article was published in the journal of Mathematical Biosciences.

Telford, A., Cavers, S., Ennos, R.A., Cottrell, J.E. (2014). Can we protect forests by harnessing variation in resistance to pests and pathogens?, *Forestry: An International Journal of Forest Research*, Volume 88, Issue 1, January 2015, Pages 3–12, https://doi.org/10.1093/forestry/cpu012

This source is a review of a compilation of research articles focused on the ability and need to prevent the effects of invasive pests and diseases on our urban and natural forests. The main topics reviewed in this article are the mechanisms of resistance, genetic control of variation in disease resistance traits, the role of environmental variation on disease resistance traits, and the phenotypic variation in tree populations. The authors of this

review are credible as they are members of the University of Edinburgh in conjunction with researchers from the Bush Estate and Northern Research Station in Midlothian. This review compiles current knowledge on preventive genetic research of forest resilience to exotic pests and diseases.

Tubby, K.V., Webber, J.F., (2010). Pests and diseases threatening urban trees under a changing climate, *Forestry: An International Journal of Forest Research*, Volume 83, Issue 4, October 2010, Pages 451–459.

This is a 7-page peer reviewed scientific article published in 2010. The article discusses how the changing climate is most likely to increase the level of stress of trees and other plants. With increased stress, this may affect trees and plants' ability to fight off certain pests and diseases. While this article is mainly placed in Britain, climate change is prevalent everywhere and this article and the research offers further knowledge into how climate change will affect trees and their susceptibility. The article offers insight into ways that foresters and citizens are able to get involved to increase monitoring and the spread of knowledge. The study stressed they need to raise awareness of the risks of native and non native pests and how the risks can be countered. This source is credible as it is published through the Centre of Forestry and Climate Change.

Author Index:

Bohlen, P. J., Scheu, S., Hale, C. M., McLean, M. A., Migge, S., Groffman, P. M., & Parkinson, D. (2004). Non-native invasive earthworms as agents of change in northern temperate forests. *Frontiers in Ecology and the Environment*, *2*(8), 427–435.

Budde, Nielsen, L. R., Ravn, H. P., & Kjær, E. D. (2016). The Natural Evolutionary Potential of Tree Populations to Cope with Newly Introduced Pests and Pathogens—Lessons Learned From Forest Health Catastrophes in Recent Decades. Current Forestry Reports, 2(1), 18–29. https://doi.org/10.1007/s40725-016-0029-9

Castello, J. D., & Teale, S. A. (Eds.). (2011). *Forest health: an integrated perspective*. Cambridge University Press.

Cech, F. C., Collins, W. H., Flemer, W., Gabriel, W. J., Gerhold, H. D., Karnosky, D., Little, S., Orton, E. R., Santamour, F. S., Steiner, K., Townsend, A. M., Valentine, F. A., & Westfall, R. T. (1982). *Genetic improvement and urban trees: A problem analysis for environmental forestry research*. *Hathi Trust*. The Group. Retrieved April 19, 2022, from https://catalog.hathitrust.org/Record/007397019/Home.

Ciesla, W. (2011). *Forest entomology: a global perspective*. John Wiley & Sons.

Dix, M.E., Johnson, R.J., Harrell, M.O. *et al.* Influences of trees on abundance of natural enemies of insect pests: a review. *Agroforest Syst* 29, 303–311 (1995).

Freer-Smith, P.H., Webber, J.F. (2017). Tree pests and diseases: the threat to biodiversity and the delivery of ecosystem services. *Biodivers Conserv* 26, 3167–3181.

Hauer, Hanou, I. S., & Sivyer, D. (2020). Planning for active management of future invasive pests affecting urban forests: the ecological and economic effects of varying Dutch elm

disease management practices for street trees in Milwaukee, WI USA. Urban Ecosystems, 23(5), 1005–1022. https://doi.org/10.1007/s11252-020-00976-6

Holdenrieder, O., Pautasso, M., Weisberg, P. J., & Lonsdale, D. (2004). Tree diseases and landscape processes: the challenge of landscape pathology. *Trends in Ecology & Evolution*, *19*(8), 446-452.

Leach, H., Biddinger, D. J., Krawczyk, G., Smyers, E., & Urban, J. M. (2019). Evaluation of insecticides for control of the spotted lanternfly, Lycorma delicatula, (Hemiptera: Fulgoridae), a new pest of fruit in the Northeastern U.S. *Crop Protection*, *124*, 104833. https://doi.org/10.1016/j.cropro.2019.05.027

Long, L. C., D'Amico, V., & Frank, S. D. (2019). Urban forest fragments buffer trees from warming and pests. *Science of the Total Environment*, *658*, 1523-1530.

Lundquist, J.E., Hamelin, R.C. (2005). *Forest pathology: from genes to landscapes*. The American Phytopathological Society.

Lundquist, J. E., & Klopfenstein, N. B. (2001). Integrating concepts of landscape ecology with the molecular biology of forest pathogens. *Forest Ecology and Management*, *150*(3), 213-222.

Macpherson, M. F., Kleczkowski, A., Healey, J. R., Quine, C. P., & Hanley, N. (2017). The effects of invasive pests and pathogens on strategies for Forest Diversification. *Ecological Modeling*, *350*, 87–99. https://doi.org/10.1016/j.ecolmodel.2017.02.003

Nemec, K. T., Allen, C. R., Alai, A., Clements, G., Kessler, A. C., Kinsell, T., Major, A., & Stephen, B. J. (2011). Woody Invasions of Urban Trails and the Changing Face of Urban

Forests in the Great Plains, USA. *The American Midland Naturalist*, *165*(2), 241–256. https://doi.org/10.1674/0003-0031-165.2.241

Norman-Burgdolf, & Rieske, L. K. (2021). Healthy trees – Healthy people: A model for engaging citizen scientists in exotic pest detection in urban parks. Urban Forestry & Urban Greening, 60, 127067–. https://doi.org/10.1016/j.ufug.2021.127067

Paap, T., Wingfield, M. J., Burgess, T. I., Hulbert, J. M., & Santini, A. (2020). Harmonizing the fields of invasion science and forest pathology. *NeoBiota*, *62*, 301.

Ploetz, R. C., Hulcr, J., Wingfield, M. J., & De Beer, Z. W. (2013). Destructive tree diseases associated with ambrosia and bark beetles: black swan events in tree pathology?. *Plant disease*, *97*(7), 856-872.

Poland, Therese M.; McCullough, Deborah G. 2006. Emerald Ash Borer: Invasion of the Urban Forest and the Threat to North America"s Ash Resource. Journal of Forestry: April-May, 2006: 118-124

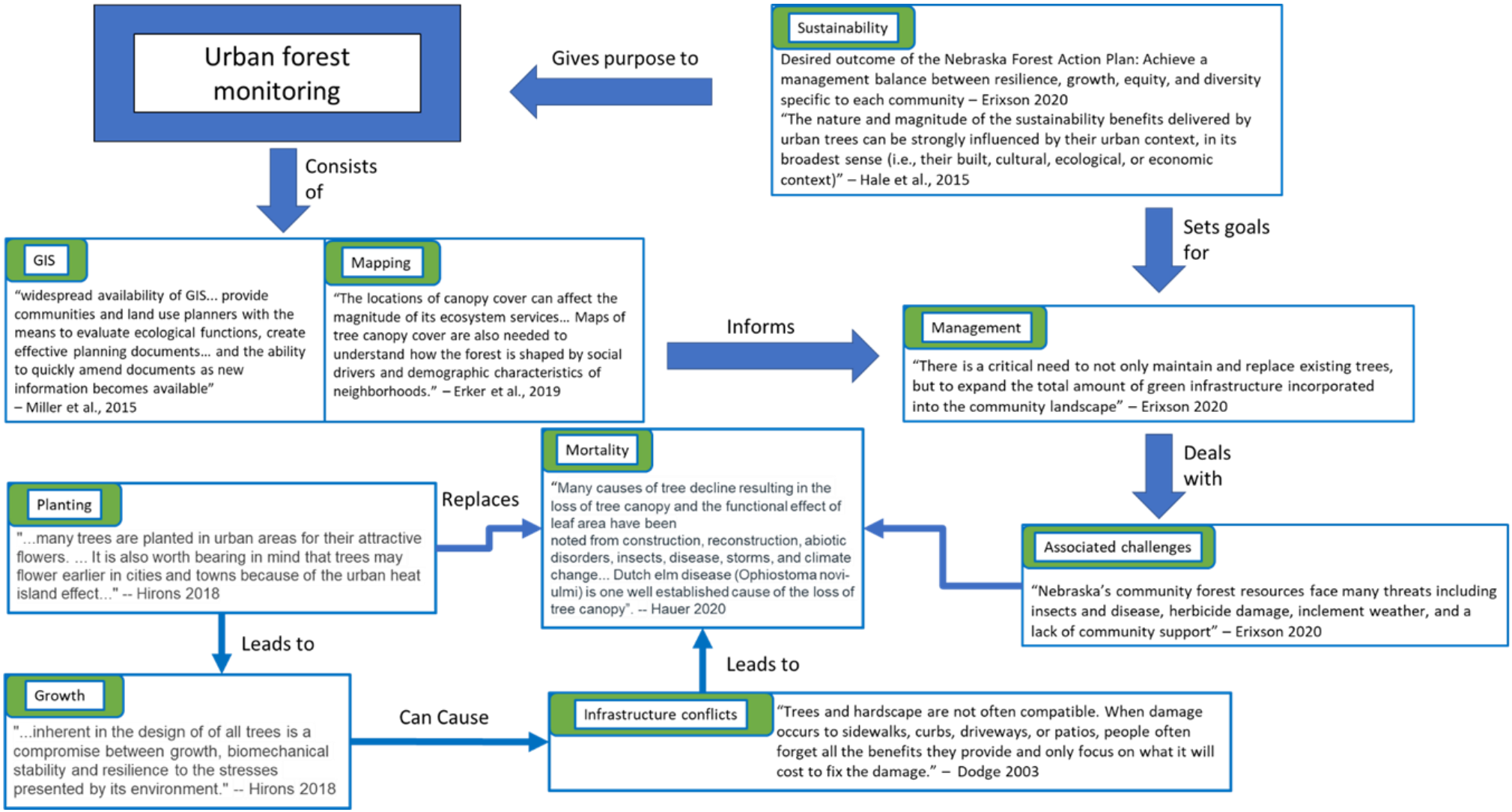
Strömbom, D., & Pandey, S. (2021). Modeling the life cycle of the spotted lanternfly (Lycorma delicatula) with management implications. *Mathematical Biosciences*, *340*, 108670. https://doi.org/10.1016/j.mbs.2021.108670

Telford, A., Cavers, S., Ennos, R.A., Cottrell, J.E. (2014). Can we protect forests by harnessing variation in resistance to pests and pathogens?, *Forestry: An International Journal of Forest Research*, Volume 88, Issue 1, January 2015, Pages 3–12, https://doi.org/10.1093/forestry/cpu012

Tubby, K.V., Webber, J.F., (2010). Pests and diseases threatening urban trees under a changing climate, *Forestry: An International Journal of Forest Research*, Volume 83, Issue 4, October 2010, Pages 451–459.

Topic 2: Urban Forest Monitoring

Theme 1: Planting
Theme 2: Growth
Theme 3: Management
Theme 4: Mortality
Theme 5: Infrastructure conflicts
Theme 6: Governance
Theme 7: Sustainability
Theme 8: GIS
Theme 9: Mapping
Theme 10: Associated challenges
Theme 11: Emerging topics


Urban forest monitoring
Gives purpose to
Sustainability
Desired outcome of the Nebraska Forest Action Plan: Achieve a management balance between resilience, growth, equity, and diversity specific to each community – Erixson 2020
"The nature and magnitude of the sustainability benefits delivered by urban trees can be strongly influenced by their urban context, in its broadest sense (i.e., their built, cultural, ecological, or economic context)" – Hale et al., 2015
Consists of
Sets goals for
GIS
"widespread availability of GIS... provide communities and land use planners with the means to evaluate ecological functions, create effective planning documents... and the ability to quickly amend documents as new information becomes available"
– Miller et al., 2015
Mapping
"The locations of canopy cover can affect the magnitude of its ecosystem services... Maps of tree canopy cover are also needed to understand how the forest is shaped by social drivers and demographic characteristics of neighborhoods." – Erker et al., 2019
Informs
Management
"There is a critical need to not only maintain and replace existing trees, but to expand the total amount of green infrastructure incorporated into the community landscape" – Erixson 2020
Deals with
Mortality
"Many causes of tree decline resulting in the loss of tree canopy and the functional effect of leaf area have been noted from construction, reconstruction, abiotic disorders, insects, disease, storms, and climate change... Dutch elm disease (Ophiostoma novi-ulmi) is one well established cause of the loss of tree canopy". -- Hauer 2020
Replaces
Planting
"...many trees are planted in urban areas for their attractive flowers. ... It is also worth bearing in mind that trees may flower earlier in cities and towns because of the urban heat island effect..." -- Hirons 2018
Associated challenges
"Nebraska's community forest resources face many threats including insects and disease, herbicide damage, inclement weather, and a lack of community support" – Erixson 2020
Leads to
Leads to
Growth
"...inherent in the design of of all trees is a compromise between growth, biomechanical stability and resilience to the stresses presented by its environment." -- Hirons 2018
Can Cause
Infrastructure conflicts
"Trees and hardscape are not often compatible. When damage occurs to sidewalks, curbs, driveways, or patios, people often forget all the benefits they provide and only focus on what it will cost to fix the damage." – Dodge 2003

Planting:

Hirons, A., & Thomas, P. A. (2018). Applied tree biology pgs 187- 231. John Wiley & Sons.

The main topics of discussion in this chapter of the "Applied Tree Biology" textbook covered topics of interest from seedlings to established trees in the urban environment. The overarching theme was "the next generation of trees" while each subtopic in the chapter broke this down into applicable knowledge for the different life cycles between seedling to young established trees. Subtopics in this chapter included: flowers, seeds, fruits, and pollination, costs of reproduction (from the tree's point of view), seasonality, significance of flowering and fruiting numbers, considerations with flower and fruit in the urban environment, tree crops and vegetation, storing seeds and seed dormancy, germination, seedlings, tree establishment, species diversity and selection, nurseries, tree quality, rooting environment, and finally arboricultural practices to help further the success of a tree. Several papers and references were mentioned throughout the text, but this source in and of itself is not a research paper. It is a guide based on peer reviewed publications on how to best prepare arborists for the next generation of successful trees in the urban setting by diving deeper into the biological significance of trees in the early stages of their life, and how these will interact with the urban environment.

Growth:

McPherson, E. G., & Peper, P. (2012). Urban Tree Growth Modeling. *Arboriculture & Urban Forestry*, *38*(5), 172–180. https://doi.org/10.48044/jauf.2012.026.

McPherson and Peper outline the difficulties associated with urban tree growth modeling: the long time scales, variety of species, and the effects of various management options. The authors

then describe how to overcome these difficulties through either of two modeling approaches: empirical or process based and hybrid models. McPherson and Paper build a massive reference database of tree growth in cities which can be mined as reference data for urban growth modeling. McPherson and Peper then use this dataset to model differential growth and ecosystem services provided by the same species in different urban areas (e.g., honeylocust growth in Westminster, Wyoming and Fort Collins, CO). Finally, the authors demonstrate how tree growth predictions can be adjusted with measurements of tree crown diameter. This article is peer reviewed, credible, and approaches urban tree growth modeling objectively. The authors hope to improve urban tree modeling to create more accurate and robust models that can be used to estimate ecosystem services of trees. This study has better informed us on urban tree growth modeling and has given more evidence to our understanding that urban tree growth is highly context dependent. The authors argue that urban tree growth modeling is in its infancy compared to other fields (e.g., forestry). This article is an important step.

Hirons, A., & Thomas, P. A. (2018). Applied tree biology pgs 15-72. John Wiley & Sons.

This chapter breaks down the biology of trees in one of the simplest forms, the trunk and branches. Much of this textbook goes into depth of the pathophysiology of trees and their environment but begins with the most basic of principles for trees. It starts by defining *what* constitutes a tree, which turns out is quite vague and all encompassing -- if it looks like a tree, it's a tree. There are several concepts talked about in this chapter, from big picture topics such as apical dominance and control, all the way to cellular level topics such as vessels, tracheids, and fibers within the wood of the tree. This chapter utilizes dozens of pictures and diagrams to help explain various concepts, including photographs of microscopic elements within a tree. This applies to urban forestry because when foresters understand the physiology of a tree, they will

better be able to care for and maintain the trees they're responsible for.

Management:

Erixson, J., Allison ,R., Ameyaw, L., Anderson, R., Clare, A., Evertson, J., Herbst, G., Frickle, M., Karloff, S., Land, C., McCartney, F., Nickerson, D., Nickless, J., Peterson, S., Rasmussen, S., Seaton, J., Shield, C., Sieber, L., Smith, J., Weyers, K., Woollen, R., Young, L. (2020). Nebraska Forest Action Plan - 2020. Nebraska Forest Service. FAP Goal 2: Manage Trees and Forest Landscapes to Include Rural and Community Forest Settings. 153-156.

Erixson et al. strategy 2 involves encouraging long-term conservation efforts to keep forests in community settings. The reasoning for doing this is because with the ever-changing effects of climate change, it has led to an increase in tree pests, diseases, and wildfires. The authors bring up their objective which is to create an environment of community tree management and planting and their approach to reach their goal/objective is use outreach, education, and training to encourage community engagement. The authors outline the challenges involved with their task like lack of knowledge and lack of funding and lack of capacity and what their plan is to overcome those challenges. The plan is a credible source, and the plan is also objective with a goal of creating an environment of community tree management and planting. The plan does not change our perspective on the topic of community forests. Lots of planning and research has to go into the planning stages and execution of their said plan, primarily when it comes to gaps in funding. The challenges that the plan faces are very strong and valid arguments but their tactics to combat their challenges are weak when it comes to a specific plan. The authors do provide some solutions to their challenges but in a broad term and not very specific with their

approaches.

Hale, J. D., Pugh, T. A. M., Sadler, J. P., Boyko, C. T., Brown, J., Caputo, S., Caserio, M., Coles, R., Farmani, R., Hales, C., Horsey, R., Hunt, D. V. L., Leach, J. M., Rogers, C. D. F., & MacKenzie, A. R. (2015). Delivering a Multi-Functional and Resilient Urban Forest. *Sustainability*, *7*, 4600–4624. https://doi.org/10.3390/su7044600.

Hale et al. argue that while ecosystem services are used to justify tree planting programs, these programs often have low survival rates that indicate that management for some individual service may not be compatible with management for another. The authors attempt to demonstrate that the best means of resolving conflicts between management for different ecosystem services is a systems-based approach. The authors collected input about the benefits and drawbacks of street tree planting and the necessary system conditions for street tree planting from experts of several fields. The authors used feedback from domain experts to build scenarios for how street tree planting may be affected if the UK were to change in some thematic ways during the street trees lifespan. In short, this article is an attempt to incorporate the values of many relevant perspectives into street tree management while recognizing that the economic, social, and political context surrounding street tree planting is dynamic. The study unifies several biased perspectives and may therefore have become objective. It is unclear, however, whether the systems-based approach solves the problems posed in this article, or that it will improve municipal forest management, first because the perspectives and complications regarding street tree planting are meant to be known to municipal forest managers, and second because these differing perspectives are treated as equally valuable when they may not be. The value of the scenarios built beyond establishing that cities are dynamic is unclear.

Miller, R. W., Hauer, R. J., & Werner, L. P. (2015). Urban forestry: planning and managing urban greenspaces. Waveland press.

The authors provide in the form of a textbook a detailed overview of the benefits, issues, and best management practices in urban forestry. The goal of the book is to educate a laymen reader on the tenets of urban forest management. It covers a wide range of topics from values associated with the urban forest (and how these may change between communities), to the formation of management plans, to practical management. This study is an excellent tertiary source for urban forestry and cites hundreds of articles; it is credible and handles its material objectively, citing its sources with proper context. This textbook provides a wealth of information about the values, planning concerns, and management practices associated with the urban forest. Miller et al. give ample examples of the points they make in each chapter. The authors also provide evidence-based solutions to management problems and recommend management practices based on where others have found success. In short, this is a great text to become knowledgeable about urban forest management and monitoring.

Sjöman, H., Hirons, A. D., & Bassuk, N. L. (2015). Urban forest resilience through tree selection—Variation in drought tolerance in *Acer*. *Urban Forestry & Urban Greening, 14*(4), 858–865. https://doi.org/10.1016/j.ufug.2015.08.004.

The authors point out that, due to factors such as root loss, limited soil volume, disruption of soil hydrologic processes, and the presence of impermeable surfaces, urban trees must contend with water stress. It is therefore advantageous for cities to select drought tolerant species for tree plantings. The authors use leaf water potential at turgor loss, an indicator of drought tolerance, among 27 species of the commonly planted *Acer* genus. The authors find a wide range of

drought tolerance of *Acer* species and argue that their technique of screening for drought tolerance will be useful in informing tree species selection for urban areas. This study is peer reviewed and objectively tests the utility of leaf water potential at turgor loss as an indicator of tolerance to a water deficit. The authors developed a useful method for screening drought tolerance in tree species. We were previously unaware of this method of screening for tree species. This article provides strong evidence for using this method as an additional screening process for tree species selection and may be an important tool for recruiting urban forests that are resilient to a warming climate.

Sjöman, H., Morgenroth, J., Sjöman, J. D., Sæbø, A., & Kowarik, I. (2016). Diversification of the urban forest—Can we afford to exclude exotic tree species? *Urban Forestry & Urban Greening*, *18*, 237–241. https://doi.org/10.1016/j.ufug.2016.06.011.

Sjöman et al. argue that there is a prevailing idea among urban forestry, urban planning, and environmental groups, and the media in North America that the urban forest ought only to include native species. Sjöman et al. argue that if restricted to native-only planting, the species catalog for urban forests may be too limited to provide a resilient urban forest. The authors also argue that the conversation about which species to plant ought to focus on the costs and benefits of species planting regarding invasion risk, biodiversity loss, and the resilience of the urban forest and associated ecosystem services. In this paper, Sjöman et al. detail a list of necessary conditions to guide the native-only vs introduced species planting for sustainable urban development. This study is peer-reviewed and adequately cites sources to establish its argument and is therefore credible. As a consequence of taking part of a debate in which values (e.g., the inherent value of native species and the inherent lack of value in introduced species) are discussed, it can be argued that this article is not objective, though that should not dissuade the

reader from valuing the arguments presented. Sjöman et al. present a strong, logical argument for approaching species selection with more nuance than "natives are good" by challenging the assumptions underlying native-only advocacy (e.g., the superiority of native species) in the urban context and providing evidence of the successful incorporation of introduced species urban development. The discussion Sjöman et al. provide is compelling and ought to be thoughtfully considered by the proponents of the native-only view.

Widney, S., Fischer, B., & Vogt, J. (2016). Tree Mortality Undercuts Ability of Tree-Planting Programs to Provide Benefits: Results of a Three-City Study. *Forests*, *7*(12), 65. https://doi.org/10.3390/f7030065.

The goal of this research paper was to use i-Tree Streets to assess the economic benefits of surviving trees in an urban setting. While trees may bring several benefits to both physical and mental health, the cost to plant and maintain trees can pose a challenge to a city. The cost of a tree is not solely the purchasing price, but the additional costs needed to transport, plant, and maintain annually or biennially. Giving trees a monetary value can help goal setting and justification into the cost of green infrastructure. The value of trees can be anywhere from $8-$20 per tree, depending on what benefits each tree bestows. Trees can help with lowering AC usage in the summer, but not every tree is going to be able to effectively shade a building to that extent. This study, presented at the 2015 ISA Area and Trade Show, found that annual survival rates of >96% are necessary in ensuring trees are providing their maximum amount of benefits during their lifetime. Each dead tree can cost a city $40-$50 in annual losses, further driving home the point of investing in care and maintenance of urban trees.

Monitoring:

Cumming, A., Twardus, D., & Nowak, D. (2008). Urban Forest Health Monitoring: Large-Scale Assessments in the United States. *Arboriculture & Urban Forestry*, *34*(6), 341–346. https://doi.org/10.48044/jauf.2008.047.

Cumming et al. propose methods developed by the U.S. Forest Service to assess urban forest structure, function, and health statewide and then demonstrate these methods in 5 pilot states: Colorado, Tennessee, New Jersey, Wisconsin, and Indiana. The method consists of sampling plots in urban areas every 6,000 acres that describe the site, trees, tree crowns, and any damage to trees and inputting results into the UFORE model. This study is thorough and peer-reviewed and is therefore credible. The authors are also forthcoming about potential shortcomings of their proposed methods and designed a method that is objective. The authors hope to establish a nationwide method for quantifying urban forest resources. This study made us aware of current data collection efforts and methods for quantifying urban forest condition, structure, and quantity. The authors provide a strong argument for their method, as well as potential difficulties in implementing it.

Nowak, D. J., Hoehn, R. E. I., Crane, D. E., & Bodine, A. R. (2012). Assessing urban forest effects and values of the Great Plains: Kansas, Nebraska, North Dakota, South Dakota (NRS-RB-71; p. NRS-RB-71). U.S. Department of Agriculture, Forest Service, Northern Research Station. https://doi.org/10.2737/NRS-RB-71.

The authors evaluate urban tree resources in the Great Plains states of Kansas, Nebraska, North Dakota, and South Dakota. The authors assess species characteristics of urban forests in the Great Plains and the extent to which these forests remove air pollutants, reduce building energy consumption, sequester, and store carbon, and the structural and functional value of these urban

forests. This report is essentially a large-scale forest composition and ecosystem services assessment for the Great Plains meant to elucidate the economic value inherent in urban forest processes. The authors find that urban forests of the Great Plains provide millions of dollars of annual ecosystem services, and that the capacity to provide these services may be endangered by improper management and disease and/or insect infestation. This study conforms to the scientific standards of the U.S. Department of Agriculture and is therefore credible. The authors employ rigorous methods to arrive at the claims they make about the value of the urban forest. Prior to reading this report, we were unaware of the regional effort to quantify the value of urban forests, much less the actual estimates derived from each state. This report is a useful companion for understanding urban forest values in the Great Plains.

Shojanoori, R., & Shafri, H. Z. M. (2016). Review on the Use of Remote Sensing for Urban Forest Monitoring. *Arboriculture & Urban Forestry*, *42*(6), 400–417.

Shojanoori and Shafri outline the need for well-maintained urban forests and the difficulties (e.g., structural complexity) around monitoring urban forests. The authors propose that remote sensing is an effective way to monitor the urban forest without the need for field measurements. The authors review and evaluate different remote sensing imagery products and classification techniques. Finally, the authors recommend using object-oriented classification of a combination of very high-resolution satellite imagery (e.g., WorldView-2, 50 cm) and LiDAR data for the best delineation of trees within the urban forest, with possible applications for tree species identification. This study offers a detailed literature review, is peer-reviewed, and is objective. The final recommendation is predictable: combining the highest possible spatial resolution data with z-axis (i.e., LiDAR) data will monitor urban trees most effectively. Our only concern with the final recommendation is that it presents a wish-list method for urban forest monitoring that

may be impractical to most forest managing agencies due to the limited availability and prohibitive cost of very high resolution and LiDAR data. For forest monitoring institutions that can overcome these limitations, this review is very useful.

Mortality:

Deborah G. McCullough & Rodrigo J. Mercader (2012) Evaluation of potential strategies to SLow Ash Mortality (SLAM) caused by emerald ash borer (Agrilus planipennis): SLAM in an urban forest, *International Journal of Pest Management*, 58:1, 9-23, DOI: 10.1080/09670874.2011.637138.

This study introduced the up-and-coming pilot program SLAM (SLow Ash Mortality) to slow the mortality of ash trees in the urban environment. Since the introduction of EAB into the U.S. back in 2002, tens of millions of ash trees have been destroyed due to this invasive species native to Asia. Management practices used in this study include girdling, insecticide, and harvested ash trees. This study also utilized simulations to help predict the efficiency of a developing systemic insecticide to help combat emerald ash borer (EAB) in the urban forest. Since ash trees are prevalent across the country in urban settings, EAB infestations cause a great deal of stress and not a lot of time to develop a plan for action. The simulations in this study help urban foresters create a basis for a plan of action that will be sufficient in saving their local ash trees. The simulation provided data that supported the insecticide (emamectin benzoate) as an economically viable asset in managing EAB, but should not be the *only* management option used. This study did a great job in addressing all challenges and mistakes made in the past, such as focusing solely on larval communities of EAB rather than addressing the adult stages as well.

Hauer, R.J., Hanou, I.S. & Sivyer, D. Planning for active management of future invasive pests affecting urban forests: the ecological and economic effects of varying Dutch elm disease management practices for street trees in Milwaukee, WI USA. *Urban Ecosyst* 23, 1005–1022 (2020). https://doi.org/10.1007/s11252-020-00976-6.

This study provides management strategies for urban forests through the lens of the Dutch Elm Disease (DED) endemic in the midwest during the last century. This information can be applicable to the new Emerald Ash Borer (EAB) problem that is ever-increasing throughout the United States. This study took into consideration both the economic and ecological factors that suffered through DED, particularly in Milwaukee, WI. The paper points out how the lack of diversity in urban forests can lead to invasive species outbreaks, and how the United States is victim to single-species forests. Because there was a lack of management, and even a lack of science behind DED, Milwaukee suffered a massive loss in their Elm population. By the mid 70s, 90% of Milwaukee's Elms had succumbed to DED. Results showed that some management proved more beneficial and less costly than no management efforts performed. A hindrance in management action can be traced back to costs of maintenance, and this conclusion helps encourage proactive steps to combat invasive pests.

Infrastructure conflicts:

Dodge, L.; Geiger, J.R. 2003**.** Tree roots and sidewalk damage. *Western Arborist*. 29(3): 28-29 https://doi.org/10.1016/j.rse.2019.03.037.

Dodge et al., in March of 2001, UC Davis held a symposium to develop strategies to reduce hardscape damage caused by tree roots. The first day, the researchers shared their findings and experiences and the second day, was devoted to developing strategies for further research and

education. Topics the researchers brought up were the total costs to fix the damage, downsizing the local tree species, soil structure, root architecture, and soil characteristics. The authors bring up conflict avoidance as street designs can be easily designed in a way for larger tree planting spaces. They also bring up that tree roots take the blame for poorly poured concrete and shrinking and expanding clay soils. On day two, the authors bring up all the further research that needs to happen in order to understand tree root and sidewalk damage. This includes, sidewalk design, alternative materials for streets and sidewalks, new instruments for remote sensing, structural soil mix, root guidance, and root and soil management: cultivar development. The contents of the article are credible and objective because of the contributors which were subject matter experts in the field of urban forest research, urban horticulture, city foresters, landscape architects, and concrete engineers. The authors and contributors hope to achieve the reduction of sidewalk damage from tree roots. This article has changed our perspective and educated us on all the choices that go along with designing city streets and sidewalks and their choices of tree species. The evidence that the article presents is strong with background knowledge on the subject of tree roots and street design and failures. The authors offer multiple solutions and recommendations as what to do including using a refined soil mix that provides increased unground pore space for tree roots and also better designed streets and landscapes with the use of monolithic street and sidewalk design. The refined soil mix is not very practical because of how much would need to be produced for the whole state of California but redesigning streets and walkways is much more practical and an easier way to solve hardscape damage from tree roots.

Hirons, A., & Thomas, P. A. (2018). Applied tree biology pgs 372-384. John Wiley & Sons.

In Chapter 10 “Environmental Challenges for Trees,” of the Applied Tree Biology textbook, there is a section dedicated to drought tolerance for difficult urban sites. In this subsection, the

authors point out that there is a wide variation in drought tolerance of trees and the physiological implications that may result, leaf turgor loss being one of the most severe. Drought is such an important ecological factor that it led to the creation of a drought tolerance scale specifically for species found in the urban environment. This scale ranks trees from (1) Very Intolerant through (5) Very Tolerant. Later in the subsection, the authors point out that some riparian species make excellent urban forest trees due to their ability to manage oxygen deficiency. The urban environment is susceptible to hypoxic conditions and impermeable soils, and since riparian species can already survive these oxygen-deficient landscapes, they are perfect candidates for planting in the urban forest. Lastly, this subsection highlighted the harmful effects of road salts on both soils and trees. The salt present will lower the osmotic potential of the soil, which directly impacts the soil water potential. This makes it harder for trees to pull water up through their roots and to the rest of the tree. From there, it is a domino effect of reduced growth, limited photosynthetic abilities, and metabolic processes slow down or even halt.

Randrup, T. B., McPherson, E. G., & Costello, L. R. (2001). Tree root intrusion in sewer systems: review of extent and costs. *Journal of Infrastructure Systems*, 7(1), 26-31. https://doi.org/10.1016/j.ufug.2016.06.011.

The authors describe how tree roots are the cause of 50% or more of the reported sewer blockages and the cost that comes with the removal of those roots is very substantial. When a sewer busts because of root damage, it takes much more money to fix the damage and is thought to be six times cheaper to conduct preventive maintenance i.e. tree root removal before the sewer collapses and must be fully replaced. The authors also bring up how older sewer systems were built with weaker materials like a yarn and cement mix which is easy for tree roots to penetrate and now materials are used that can withstand compression from roots. The authors also bring up

multiple ways of reducing tree root damage to sewers and what preventative maintenance works and what doesn't. The point of this article is to educate others on why preventative maintenance is important and what the best options are to stop tree root damage before it happens. The topics covered with preventative maintenance are, simply cutting the roots, cutting the roots and using a chemical treatment or by flooding the pipeline with scalding water to retard root regrowth, utilizing different types of fabrics to reduce the growth around the sewer system, and installing properly water tight lines so the tree roots cannot penetrate the sewer. This study is credible and uses data from cities in Sweden, United States, Canada, and Denmark. The study is objective and is informing city parks departments on the best way to manage trees near sewer systems and how to cut repair costs with the sewer system due to root damage. This study was very informative about how much goes into maintaining trees' underground roots and how often they affect sewer lines. The evidence the authors provide is not weak or strong, more moderate with that they do provide evidence that preventative maintenance is cheaper than fixing a busted pipe, but they also bring up that there is limited data available in relation to costs of sewer system maintenance specifically in relation to root intrusions. The authors do provide solutions to the tree root problem, and yes they are all practical but when it comes to the use of chemicals after cutting, it may affect the environment in the long run compared to sewer damage. And yes the solutions they have provided do solve the problem of sewer damage.

Governance:

Ordóñez, C., Threlfall, C. G., Kendal, D., Hochuli, D. F., Davern, M., Fuller, R. A., & Livesley, S. J. (2019). Urban forest governance and decision-making: A systematic review and synthesis of the perspectives of municipal managers. *Landscape and Urban Planning, 189*, 166-180.

Camilo Ordóñez et al, reviewed >1400 articles to better understand the governance and decision making by urban forest managers. Two definitions are given in the article, defining governance as "...the collection of institutions, rules, and processes of collective decision-making that allows stakeholders to influence and coordinate their needs." The definition of decision making reflects the how and why trees are planted and removed according to urban forest managers. The effort from this article is to gain insight to managerial practices and implications and what their primary influence is (operational vs management). Operational influences come from budgets and personnel, whereas management is related to coordination and time management. This objective study was published in the September 2019 publication of "Landscape and Urban Planning." An issue the researchers ran into, as is common amongst urban forestry literature review articles, is the vague or subjective nature of review, complaints, or whatever is being analyzed. This only compounds the issue of lacking monitoring strategies. The authors hope to inspire future research aimed towards gaining insight on both the governance and decision-making of urban forest managers, particularly how they understand, facilitate, and find support in managerial processes.

Sustainability:

Endreny, T. A. (2018). Strategically growing the urban forest will improve our world. *Nature Communications*, *9*, 1160.

Endreny 2018 argues that strategic management and growth of urban forests is essential to the sustainability and growth of the world's urban areas. This article consists of 4 parts: it establishes the importance of ecosystem services provided by urban forests, outlines barriers to improving urban forests (i.e., urban forest disservices), follows by highlighting some opportunities to

improve urban forests (e.g., integrating ecology, engineering, and technology), and ends by pointing out knowledge gaps and recommending a way forward (i.e., developing cities in accordance with the United Nations's sustainable development goals). This article is peer reviewed and acts more as a synthesis of research and a recommendation for proceeding with sustainability than a research article. This study clearly wishes to promote the UN's sustainable development goals and might therefore be considered biased, though the study builds this promotion upon a foundation of peer-reviewed literature. This article gives a valuable global perspective of the role of urban forests in developing sustainable cities and makes a compelling argument for promoting urban forest development and integrating engineering, city planning, technology, and urban forestry. The strength of this argument, however, may be held in doubt due to the small number of cited articles (16). It seems this article is a compelling note that promotes urban forest growth and may act as a precursor to a more in-depth analysis of the role of urban forestry in developing sustainable cities.

GIS:

American Forests. (2022). *Tree equity score*. https://www.treeequityscore.org; https://www.americanforests.org/.

Tree Equity Score is a web-based GIS tool operated by American Forests that calculates an equity score for a user-specified urban area of interest from a wide range of United States urban areas. The purpose of the tool is to provide an interactive way to investigate and promote tree equity (i.e., the equitable distribution of tree-associated ecosystem services across socio-economic groups) in the United States; the tool encourages citizen advocacy for tree planting programs to promote tree equity. The equity calculation is objective and transparent, though

there are some assumptions and gaps in the equation that may undermine Tree Equity Score's reliability as a tool to evaluate equity. For example, zoning restrictions are not considered when determining equity, so canopy cover goals are the same in industrial areas as in residential ones without considering the land use constraints around tree growth in these different zones. Ultimately, Tree Equity Score is a good tool for visualizing equity and disparities in equity across urban areas but should be used while considering the assumptions made in calculating equity, and in the physical and legal context of the census block to which each score is assigned.

Gorelick, N., Hancher, M., Dixon, M., Ilyushchenko, S., Thau, D., & Moore, R. (2017). Google Earth Engine: Planetary-scale geospatial analysis for everyone. *Remote Sensing of Environment*, *202*, 18–27. https://doi.org/10.1016/j.rse.2017.06.031.

Gorelick et al. use their publication, Google Earth Engine: Planetary-scale geospatial analysis for everyone, to introduce Google Earth Engine as an analytical platform for addressing natural resources monitoring problems.This publication is included not as a document specifically about urban forest monitoring, but as an API capable of addressing urban forest monitoring problems. The article outlines Google Earth Engine's computing capabilities, system architecture, data catalog, and offers some examples of how it can be used to address natural resource problems. This article is peer-reviewed, and the Google Earth Engine platform is widely available so be evaluated by users, so it is highly credible. It would be difficult, however, to call it objective since the article is authored by Google employees who are increasing awareness of a Google product to the scientific community. The ability of the platform to address natural resources questions in an objective manner, however, is well established in the examples provided in the paper, and the several other examples of Google Earth Engine work since (e.g., the trainings available online through the NASA ARSET program are taught through Google Earth Engine).

This article increases awareness about the Google Earth Engine platform which is a robust analytical platform. It is a powerful tool for natural resource management and Earth observation.

Mapping:

Canetti, A., Garrastazu, M. C., Mattos, P. P. de, Braz, E. M., & Pellico Netto, S. (2018). Understanding multi-temporal urban forest cover using high resolution images. *Urban Forestry & Urban Greening*, *29*, 106–112. https://doi.org/10.1016/j.ufug.2017.10.020.

Canetti et al. investigate the ability of combining imagery from different satellite sensors to accurately map the effect of urbanization on urban forest resources. The authors use multi-temporal SPOT and RapidEye imagery to classify the municipality of Araucaria, Brazil using an object-oriented classification method to investigate the effects of urbanization on urban forest resources. They found that a multi-sensor, multi-temporal approach was sufficient to map urban forest resources, and that urban forest cover has decreased with the concurrent increase in urbanization. This study is peer-reviewed and credible, and handles the question of multi-sensor, multi-temporal image classification objectively. Their approach is innovative in that it demonstrates that multiple sensors can be used to compare imagery, which is typically not done in scientific analysis, though is likely permissible in this case because the authors compare classified images rather than using raw digital numbers. The authors make a strong case that this method of classification is legitimate and can be used to map urban forest change over time.

Coleman, R. W., Stavros, N., Yadav, V., & Parazoo, N. (2020). A simplified framework for high-resolution urban vegetation classification with optical imagery in the Los Angeles megacity. *Remote Sensing*, 12(15), 2399. https://doi.org/10.3390/rs12152399.

Coleman et al. argue that urban land cover maps (including maps of urban vegetation) are critical to understanding the heterogeneity of the urban environment. The authors develop a method to accurately classify a large spatial domain (the Los Angeles megacity area) with high spatial resolution imagery (1 m NAIP imagery). Their method of NAIP classification builds on the method developed by Erker et al. 2019, with the particular development of being able to reclassify shadows, a common source of error in high resolution imagery classification, by using Sentinel-2 median image composites. Ultimately, they develop a highly accurate method for classifying urban land cover, including urban vegetation. This study seems to be credible as it is peer-reviewed and published in the journal Remote Sensing, and handles urban land cover classification in an objective, scientific manner. This study increased our understanding of urban land cover classification and reclassification of shadows in high spatial resolution imagery, which is critical for developing accurate, spatially-explicit estimates of urban forest cover. The evidence presented by Coleman et al. for the success of their method is strong, and their method of handling shadows will be useful for high spatial resolution urban land cover classification tasks.

Erker, T., Wang, L., Lorentz, L., Stoltman, A., & Townsend, P. A. (2019). A statewide urban tree canopy mapping method. *Remote Sensing of Environment*, 229, 148–158. https://doi.org/10.1016/j.rse.2019.03.037.

Erker et al. classify urban forests in the state of Wisconsin testing different sources of imagery (SPOT and NAIP) and various machine learning classifiers (support vector machines, random forest, and gradient boosted trees). Erker et al. develop this method so that municipal managers have a means to develop spatially explicit urban forest maps with low cost or free imagery. This article finds that it is possible to develop reasonably accurate maps (80-85% accuracy) over large

urban extents without great financial expenditures. This article is peer-reviewed and thoroughly tests its methods, so it is objective and credible. The authors successfully provide a method for creating spatially explicit urban forest maps, which is important for monitoring urban forest condition, tree cover change, and how various factors contribute to urban tree canopy cover. This study provides strong evidence that its proposed method of land cover classification is robust and accurate. We learned that the choice of machine learning classifier does not significantly change the end map's accuracy, and that urban forest monitoring can be done in a cost-effective manner.

Associated challenges:

Roman, L. A., McPherson, E. G., Scharenbroch, B. C., & Bartens, J. (2013). Identifying common practices and challenges for local urban tree monitoring programs across the United States. *Arboriculture & Urban Forestry*. 39 (6): 292-299., 39(6), 292-299.

Roman et al. focused this research article on common goals and challenges affecting urban tree monitoring. The goal of this research effort was to find a standardized approach to urban tree monitoring that could be adapted to various communities' needs. The authors surveyed 32 urban tree programs and organizations across the United States to compile a list of commonalities; goals, challenges, things that work well, etc. One challenge the authors faced was staffing discrepancies; nearly half the participating entities (nonprofits, state agencies, municipal agencies, and utilities) had a maximum of six staffers. Minimal funding only exacerbated this issue. A common goal across participants was the idea of descriptive data as opposed to the typically vague data entries they had to work with. This article, published by the International Society of Arboriculture, highlighted the sad reality that few urban tree organizations are staffed with professionals. It also helped us realize the importance of descriptive data -- what exactly is

the issue, versus an oversimplified, highly subjective comment.

Author Index:

Hirons, A., & Thomas, P. A. (2018). Applied tree biology pgs 187- 231. John Wiley & Sons.

McPherson, E. G., & Peper, P. (2012). Urban Tree Growth Modeling. *Arboriculture & Urban Forestry*, *38*(5), 172–180. https://doi.org/10.48044/jauf.2012.026.

Erixson, J., Allison ,R., Ameyaw, L., Anderson, R., Clare, A., Evertson, J., Herbst, G., Frickle, M., Karloff, S., Land, C., McCartney, F., Nickerson, D., Nickless, J., Peterson, S., Rasmussen, S., Seaton, J., Shield, C., Sieber, L., Smith, J., Weyers, K., Woollen, R., Young, L. (2020). Nebraska Forest Action Plan - 2020. Nebraska Forest Service. FAP Goal 2: Manage Trees and Forest Landscapes to Include Rural and Community Forest Settings. 153-156.

Hale, J. D., Pugh, T. A. M., Sadler, J. P., Boyko, C. T., Brown, J., Caputo, S., Caserio, M., Coles, R., Farmani, R., Hales, C., Horsey, R., Hunt, D. V. L., Leach, J. M., Rogers, C. D. F., & MacKenzie, A. R. (2015). Delivering a Multi-Functional and Resilient Urban Forest. *Sustainability*, *7*, 4600–4624. https://doi.org/10.3390/su7044600.

Miller, R. W., Hauer, R. J., & Werner, L. P. (2015). Urban forestry: planning and managing urban greenspaces. Waveland press.

Sjöman, H., Hirons, A. D., & Bassuk, N. L. (2015). Urban forest resilience through tree selection—Variation in drought tolerance in *Acer*. *Urban Forestry & Urban Greening*, *14*(4), 858–865. https://doi.org/10.1016/j.ufug.2015.08.004.

Sjöman, H., Morgenroth, J., Sjöman, J. D., Sæbø, A., & Kowarik, I. (2016). Diversification of the urban forest—Can we afford to exclude exotic tree species? *Urban Forestry & Urban*

Greening, *18*, 237–241. https://doi.org/10.1016/j.ufug.2016.06.011.

Widney, S., Fischer, B., & Vogt, J. (2016). Tree Mortality Undercuts Ability of Tree-Planting Programs to Provide Benefits: Results of a Three-City Study. *Forests*, *7*(12), 65. https://doi.org/10.3390/f7030065.

Cumming, A., Twardus, D., & Nowak, D. (2008). Urban Forest Health Monitoring: Large-Scale Assessments in the United States. *Arboriculture & Urban Forestry*, *34*(6), 341–346. https://doi.org/10.48044/jauf.2008.047.

Nowak, D. J., Hoehn, R. E. I., Crane, D. E., & Bodine, A. R. (2012). Assessing urban forest effects and values of the Great Plains: Kansas, Nebraska, North Dakota, South Dakota (NRS-RB-71; p. NRS-RB-71). U.S. Department of Agriculture, Forest Service, Northern Research Station. https://doi.org/10.2737/NRS-RB-71.

Shojanoori, R., & Shafri, H. Z. M. (2016). Review on the Use of Remote Sensing for Urban Forest Monitoring. *Arboriculture & Urban Forestry*, *42*(6), 400–417.

Deborah G. McCullough & Rodrigo J. Mercader (2012) Evaluation of potential strategies to SLow Ash Mortality (SLAM) caused by emerald ash borer (Agrilus planipennis): SLAM in an urban forest, *International Journal of Pest Management*, 58:1, 9-23, DOI: 10.1080/09670874.2011.637138.

Hauer, R.J., Hanou, I.S. & Sivyer, D. Planning for active management of future invasive pests affecting urban forests: the ecological and economic effects of varying Dutch elm disease management practices for street trees in Milwaukee, WI USA. *Urban Ecosyst* 23, 1005–1022 (2020). https://doi.org/10.1007/s11252-020-00976-6.

Dodge, L.; Geiger, J.R. 2003**.** Tree roots and sidewalk damage. *Western Arborist*. 29(3): 28-29 https://doi.org/10.1016/j.rse.2019.03.037.

Randrup, T. B., McPherson, E. G., & Costello, L. R. (2001). Tree root intrusion in sewer systems: review of extent and costs. *Journal of Infrastructure Systems*, 7(1), 26-31. https://doi.org/10.1016/j.ufug.2016.06.011.

Ordóñez, C., Threlfall, C. G., Kendal, D., Hochuli, D. F., Davern, M., Fuller, R. A., & Livesley, S. J. (2019). Urban forest governance and decision-making: A systematic review and synthesis of the perspectives of municipal managers. *Landscape and Urban Planning*, *189*, 166-180.

Endreny, T. A. (2018). Strategically growing the urban forest will improve our world. *Nature Communications*, *9*, 1160.

American Forests. (2022). *Tree equity score.* https://www.treeequityscore.org; https://www.americanforests.org/.

Gorelick, N., Hancher, M., Dixon, M., Ilyushchenko, S., Thau, D., & Moore, R. (2017). Google Earth Engine: Planetary-scale geospatial analysis for everyone. *Remote Sensing of Environment*, *202*, 18–27. https://doi.org/10.1016/j.rse.2017.06.031.

Canetti, A., Garrastazu, M. C., Mattos, P. P. de, Braz, E. M., & Pellico Netto, S. (2018). Understanding multi-temporal urban forest cover using high resolution images. *Urban Forestry & Urban Greening*, *29*, 106–112. https://doi.org/10.1016/j.ufug.2017.10.020.

Coleman, R. W., Stavros, N., Yadav, V., & Parazoo, N. (2020). A simplified framework for

high-resolution urban vegetation classification with optical imagery in the Los Angeles megacity. *Remote Sensing*, 12(15), 2399. https://doi.org/10.3390/rs12152399.

Erker, T., Wang, L., Lorentz, L., Stoltman, A., & Townsend, P. A. (2019). A statewide urban tree canopy mapping method. *Remote Sensing of Environment*, 229, 148–158. https://doi.org/10.1016/j.rse.2019.03.037.

Roman, L. A., McPherson, E. G., Scharenbroch, B. C., & Bartens, J. (2013). Identifying common practices and challenges for local urban tree monitoring programs across the United States. *Arboriculture & Urban Forestry*. 39 (6): 292-299., 39(6), 292-299.

Topic 3: Urban Forests, the Environment, and Climate Change

Theme 1: Ecosystem benefits

Theme 2: Climate change (including policy)

Theme 3: Carbon sequestration

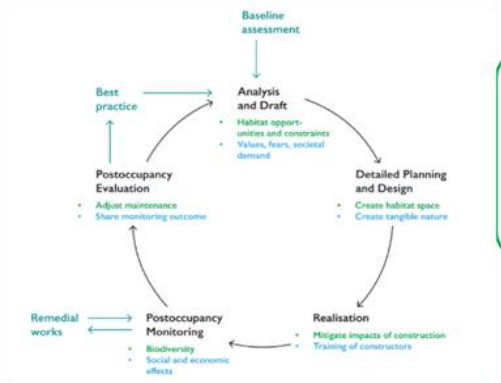
Theme 4: Environmental services

Theme 5: Wildlife in urban areas

Theme 6: Associated challenges

Theme 7: Emerging topics

Urban Forests, the Environment and Climate Change



"The respondents used the natural areas for a wide range of activities including exercise, connecting nature, dog walking, seeking peace and quiet, time with family, and socializing to name a few."

Wildlife

Effects of habitat structure, human disturbance, and habitat connectivity on urban forest bird communities (Kang et al., 2015)

Human Health

The Importance of Urban Natural Areas and Urban Ecosystem Services During the COVID-19 Pandemic (Grima et al.)

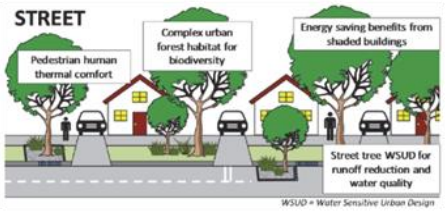
Supports

Associated Challenges:
"The expansion of the urban environment leads to an increase of impervous surfaces and stormwater runoff which increases harmful pollutants that flow into constructed and natural water systems resulting in potential health risks, and increased costs for water treatment programs."

Includes

The urban forest and ecosystem services: impact on urban water, heat, and pollution cycles at the tree, street, and city scale (Livesley et al., 2016)

Environmental Services



Includes

Urban Forests

Provides

Ecosystem Benefits

Includes

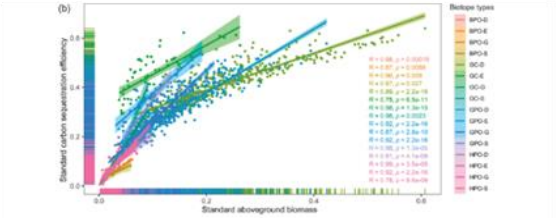


Fig. 9. (a) Spatial distribution of aboveground biomass. (b) Relationship between aboveground biomass and carbon sequestration efficiency in different biotope types.

Carbon Sequestration

Promoting sustainable carbon sequestration of plants in urban greenspace by planting design: A case study in parks of Beijing - (Wang et al., 2021)

Negatively Impacts

Benefits

Provides

Driver Of

Associated Challenges:
Municipal level green infrastructure strategies for removing air pollutants would have a limited effect on air quality levels and GHG emissions, however, can play a complementary role to other air quality and climate change policies

Includes

Climate Change: Mitigation

Contribution of Ecosystem Services to Air Quality and Climate Change Mitigation Policies: The Case of Urban Forests in Barcelona, Spain - (Baró et al., 2014)

Table 4 Contribution of urban forests on air quality and climate change mitigation (year 2008)

Air pollutant	Removal biophysical value (t year^{-1})	Removal monetary value (USD year^{-1})	City-based emissions (t year^{-1})	Background pollution influence (%)	Ecosystem Service contribution (%)	
					City-based emissions	City-based emissions and background pollution
PM_{10}	166.01	1 097 964	743.77	88.10	22.32	2.66
NO_2	54.59	540 745	10 412.94	18.70	0.52	0.43
CO_2eq	19 036	407 177	4 053 766	N/A	0.47	N/A
			84 403*		22.55*	

* CO_2eq emissions from services and activities directly managed by the City Council ("Covenant of Mayors" policy target baseline emissions)

Climate Change:

Baró, F., Chaparro, L., Gómez-Baggethun, E., Langemeyer, J., Nowak, D. J., & Terradas, J. (2014). Contribution of Ecosystem Services to Air Quality and Climate Change Mitigation Policies: The Case of Urban Forests in Barcelona, Spain. *Ambio*, *43*(4), 466–479.

This paper examines how to understand and quantify the positive effects that urban forests have on global and city-level climate change in Barcelona, Spain. There are two objectives that the researchers hoped to achieve with this research. The first was to quantify the benefits of urban forests in biophysical and monetary terms. Second, they evaluated whether or not the differences urban forests have in regulating the issues of city-level air pollution and climate change would be enough to implement them as solutions on a policy level, in an attempt to prove that policy targets could be based on the concepts of urban forest management. They concluded that municipal level green infrastructure strategies for removing air pollutants would have a limited effect on air quality levels and GHG emissions, however, can play a complementary role to other air quality and climate change policies. Through the reading of this article, one can make the assessment that green infrastructure-based strategies will need to be implemented at a broader spatial scale, such as metropolitan area scales, to have a stronger effect on the effects of air quality improvement in regard to air pollutants and GHG emissions. This article provided an effective overview of the concept of quantifying the effects urban forests have on climate change and implementing effective planning strategies to help fight climate change through urban forests.

Carbon Sequestration:

Wang, Y., Chang, Q., & Li, X. (2021). Promoting sustainable carbon sequestration of plants in urban greenspace by planting design: A case study in parks of Beijing. *Urban Forestry & Urban Greening*, *64*, 127291.

This study was conducted in the city of Beijing, China as a way to research how different planting design practices can impact the effectiveness of carbon sequestration in urban forests. The goal is to develop a framework of the most effective methods of planting design for particular biotope structures so that landscape architects and landscape designers can use planting as an effective tool to help combat climate change when working in an urban setting. The researchers found through these analyses, that dense tree planting is not necessary for high carbon sequestration efficiency, as partly open green spaces and closed greenspaces surrounded by high tree coverage were also very effective in carbon sequestration. The information within this article can help the reader make the assessment that medium-sized biotopes and plants with partly open structures are an effective method of sequestering carbon when using plants that are highly effective at carbon sequestration. This article was very interesting as I was able to find reasoning for my advocacy for varying plant sizes in the different biotopes to most effectively utilize the planted space while still having open space.

Environmental Services:

Nowak, D. J., Hirabayashi, S., Doyle, M., McGovern, M., & Pasher, J. (2018). Air pollution removal by urban forests in Canada and its effect on air quality and human health. *Urban Forestry & Urban Greening*, *29*, 40-48.

The article sheds a light on the ecosystem services provided by urban trees in Canada including air pollution reduction, carbon sequestration, cooling air temperatures, and aesthetic beauty. Multiple studies have aimed at quantifying the economic impacts of urban trees, but only a few have extensively looked at the health benefits provided by the urban landscape. Computer

simulations with local environmental data have shown that in 2010, 16500 tons of air pollution were removed in 86 Canadian cities; that amount would have cost 227.2 million Canadian dollars in health expenses. The air pollution removal varied from city to city depending on the abundance of trees and the particle deposition velocities. 1740 t, 1470 t, and 1400 t of air pollution were removed in Vancouver, Toronto, and Montreal respectively. The monetary value associated with those removals was $16.2 million in Vancouver, $25.4million in Toronto, and $31.4 million in Montreal. Air pollution removal prevented 30 potential deaths per year, 21900 potential acute respiratory symptoms, 16500 asthma incidences, and 4500 school loss days. However, urban trees can pose a threat to urban residential areas if the pollutants are trapped on the leaf surface for a long time or deflected away from people. A thorough understanding of environmental and social variables that affect the location of the trees is key to maintaining resilient forests in urban and peri-urban areas.

Livesley, S. J., McPherson, E. G., & Calfapietra, C. (2016). The urban forest and ecosystem services: impact on urban water, heat, and pollution cycles at the tree, street, and city scale. *Journal of Environmental Quality. 45: 119-124*, *45*, 119-124.

The article states, with the increasing problems surrounding the urban landscape, such as urban water and stormwater runoff, urban heat islands and summer heatwaves, soil and water pollution, and chemical and particulate pollution in urban air, the urban forest is a suitable way for cities or towns to manage those surrounding urban landscape problems. Urban forests or trees have shown they are an integral part of the urban environmental quality. They promote awareness of ways they can contribute to ecosystem services like energy conservation, carbon storage, stormwater runoff reduction, air quality improvement, and human health and well-being enhancement. However, to implement these strategies, urban policymakers, planners, and managers need a shred of evidence that implies these strategies are sufficient and efficient. Many

of the urban landscape problems result from the increase of impervious surface cover, mainly paved or cemented surfaces. Impervious surfaces can result in an increase in stormwater runoff, flash flooding, heat island area, energy use, and summer heatwaves. Therefore, urban forests can help reduce nutrient pollution concentration in run-off catchments and volatile gaseous concentrations that are suspended in the air. They also influence the carbon sequestration capacity while providing shade to gradually reduce the intensity of heat islands in urban landscapes. The article provided an interesting overview of how urban forests promote a variety of ways to contribute to ecosystem services around the urban landscape.

Seitz, J., & Escobedo, F. (2008). Urban forests in Florida: Trees control stormwater runoff and improve water quality. *EDIS*, *2008*(5).

The loss of natural forests is caused by the increasing development of urban areas, allowing stormwater runoff to increase, consequently declining the water quality drastically. With an increase in stormwater runoff, there is a subtle incline of pollutants and chemicals that flow into many water supply systems and other water bodies located near urban areas. Resulting in potential health risks and increasing tax payments for water treatment programs. With implanting urban forests around a community, it can weaken the effects of those potential damages. Therefore, planting individual trees or urban forests allows their canopy cover to assist in maintaining watershed health, improving water and soil quality, and lowering maintenance costs for water treatment programs. They are capable of intercepting rainfall through root uptake or leaf catchment. However, rainfall interception varies amongst tree species, tree density, lower canopy vegetation, climate, and tree location. Although each tree may vary for rainfall interception, they are all essential for decreasing stormwater runoff and its potential damages. Hence, maintaining and planting trees in strategic areas will increase the potential for stormwater absorption and help decrease water pollutants that could harm a water treatment facility.

Strategic tree plantings that are located in drainage systems can be utilized to reduce the harmful pollutants or chemicals such as fertilizers, heavy metals, pesticides, and bacteria from roadways or sidewalks. Thus, trees and other vegetation are valuable components of urban landscapes and ecosystems if they are properly managed and maintained to correctly interfere with stormwater runoff. The article was informative about how urban forests can effectively control stormwater runoff, and ultimately through that process, improve water quality in the urban environment.

Ecosystem Benefits:

Grima, N., Corcoran, W., Hill-James, C., Langton, B., Sommer, H., & Fisher, B. (2020). The importance of urban natural areas and urban ecosystem services during the COVID-19 pandemic. *PloS one*,*15*(12), e0243344.

The article assesses the importance of ecosystem services in urban and peri-urban areas during the time of the COVID-19 global pandemic. 400 people around Burlington, VT were surveyed to compare the frequency of visiting 25 urban and peri-urban natural areas before and during the pandemic. The results showed that 69% of the respondents had increased or greatly increased their visitation to urban forests, and 80% of them attached great importance to access to those ecosystem benefits. Of the 400 respondents, 25.8% had never or rarely visited their natural areas before the global pandemic; however, a high percentage of them (69.2%) reported access to the urban forests and natural areas as ‘very important.’ The respondents used the natural areas for a wide range of activities including exercise, connecting nature, dog walking, seeking peace and quiet, time with family, and socializing to name a few. The zoonotic diseases experts claim that there is a potential for future pandemics; this necessitates a consideration of the material and non-material benefits provided by natural areas. Moreover, the funds associated with safeguarding the natural areas need to be properly managed to ensure that the ecosystem services provided by the natural areas are available for current and future generations.

Jim, Chi Yung, and Wendy Y. Chen. "Ecosystem services and valuation of urban forests in China." *Cities* 26.4 (2009): 187-194.

The article discusses some of the histories behind the origin of urban vegetation planting in China as well as the various services provided today by the urban forest. Serious urban greening likely began with royal palace gardens and became more widespread from there. Today the urban forest provides various services such as regulating services, microclimate services, and cultural services. Urban forests of China provide regulating services by removing pollutants from the air making it cleaner to breathe. Specifically, studies have been done to see how well urban forests are able to remove sulfur dioxide particles from the air. In many places, urban forests provide microclimate services by shading areas and cooling them creating a more comfortable environment but many urban areas of China have large high-rise buildings which accomplish this effect already. That does not mean that the trees do not still provide relief, however. By measuring the evapotranspiration that occurs around trees a type of oasis effect can be observed where the areas around the trees are more humid creating a more comfortable environment. Cultural services come in a wide variety of ways and can be different for everyone. Urban forests provide opportunities for education, and spaces for recreation, and bring a sense of peace among other things.

Nesbitt, Lorien, et al. "The social and economic value of cultural ecosystem services provided by urban forests in North America: A review and suggestions for future research." *Urban Forestry & Urban Greening* 25 (2017): 103-111.

This paper brings together various articles in order to describe different ways the urban forest impacts our health as well as various economic benefits provided by urban forests. Green spaces provide areas for recreational activities and promote exercise. Even small amounts of daily exercise can have long-lasting positive impacts on our physical health. Many studies have also shown that urban populations receive mental health benefits from our urban forests. Populations

receive these benefits whether they are viewing them from a window or walking out in the green spaces. Some studies showed that children who were diagnosed with ADHD were able to concentrate better after a 20-minute walk through the park compared to those who went on a 20-minute walk in a downtown area with fewer green spaces. Urban populations' social health is also improved by the presence of these green spaces. Having these community areas promotes socialization among community members. There are also monetary benefits to having trees in our urban environments. Property values increase significantly when houses are adjacent to green spaces and having well-established trees on your own property can also improve property value. Houses that have these older established trees also tend to sell quicker than houses that have no trees or young trees. Having attractive green spaces also helps to improve tourism in an area and brings further economic gain. On top of attracting tourism, there is anecdotal evidence that green spaces can influence business decisions. Having more attractive green spaces could potentially promote new businesses to come to the area creating cascading economic effects.

Manes, F., Incerti, G., Salvatori, E., Vitale, M., Ricotta, C., & Costanza, R. (2012). Urban ecosystem services: tree diversity and stability of tropospheric ozone removal. *Ecological Applications*, *22*(1), 349–360.

The article discusses how the values of urban tree diversity affect tropospheric ozone (O_3) removal in Rome, Italy in 2003 and 2004. Three different tree functional groups, the plant's physiology, abundance, and distribution within urban areas are parameters that have an effect on the magnitude and efficiency of air pollution removal. However, those three functional groups and their magnitude and efficiency are also determined by the tree diversity within that urban area. In 2003 and 2004, ozone uptake was different among evergreen broadleaves, deciduous broadleaves, and conifers. In the spring of both years, deciduous broadleaves displayed the highest and conifers showed the lowest stomatal O_3 fluxes. In the 2003 summer, deciduous broadleaves had reduced stomatal O_3 flux due to limiting environmental conditions, whereas

evergreen broadleaves maintained high levels of stomatal O_3 fluxes, and conifers increased in O_3 uptake. However, in the fall, deciduous broadleaves showed greater values than conifers and evergreen broadleaves. The trees' ability to remove ozone pollutants is a result of four factors: tree cover, plant physiology, leaf season length, and air ozone concentration. These four factors are mainly affected by environmental conditions that occur throughout each season. Therefore, the results from each tree species can vary throughout the different seasons. Developing future management programs or strategies, such as strategic tree plantings around an urban area would be beneficial for increasing ozone uptake in trees. From this article, I understood how tree diversity and different tree functional groups can affect the magnitude and efficiency of tropospheric ozone removal in the urban environment.

Wildlife in Urban Areas:

Fidino, Mason A., Elizabeth W. Lehrer, and Seth B. Magle. "Habitat dynamics of the Virginia opossum in a highly urban landscape." *The American Midland Naturalist* 175.2 (2016): 155-167.

The article discusses the habitat needs of Opossums in the city of Chicago and compares the findings to previous studies done in smaller settings. Up to this point, this study was the largest urban area used to study the habitat dynamics of the Virginia opossum. They chose to study opossums specifically because they are a relatively short-lived species so you could watch multiple generations in a relatively short period and because they are very adaptive and are present in most urban areas. While other studies had found that water was not a crucial need for opossums when choosing denning locations, in highly urban areas where water sources are less prevalent, distance to natural water sources became a crucial factor for denning locations. Another factor that led to their choice of denning location was the amount of canopy cover and green space available for denning. Opossums were less likely to nest near trees where the grass

was maintained, and the cover was minimal and would often be found where there were significant amounts of vegetation beneath the tree's cover. They were less likely to be found near areas without a high amount of impervious surface cover and usually chose to stay in green spaces or residential areas with covers in landscapes and anthropogenic water sources. As long as opossums can find canopy cover and a source of water then this highly adaptive animal will continue to make its home among our urban landscapes foraging for any food we may leave behind for it.

Kang, W., Minor, E. S., Park, C. R., & Lee, D. (2015). Effects of habitat structure, human disturbance, and habitat connectivity on urban forest bird communities. *Urban ecosystems*, *18*(3), 857-870.

The article discusses how habitat structure, human disturbance, and habitat connectivity affect bird communities around urban forests. Since bird communities have a large impact on the functions of the natural food web and ecosystem services, examining and understanding their connections within the urban forest is quite significant. Although most urban forests equate to a smaller forested area, they still provide a well-connected green space network with many resources and habitats for various wildlife species that could increase overall biodiversity in an urban environment. Therefore, maintaining or enhancing a green space around an urban area could increase the overall bird biodiversity. However, human disturbance, such as walking, running, biking, etc., is a major problem that decreases bird communities around the urban forest. Depending on the size of the patch area, the abundance of bird species and diversity varied. Since smaller forested patch areas are found in more urban locations than rural, humans have a larger detrimental impact on the bird community in an urban forest than in a rural forest. Smaller patches with a lower level of human disturbances had a higher species abundance and diversity. Moreover, establishing more lower-lying vegetation (shrubs) in an urban forest could

introduce new habitats for bird communities that usually nest in those areas. However, human disturbances are capable of affecting those habitats and decreasing those newly established bird species. Thus, restricting any human activities by plotting fences around an area could withdraw human disturbances and increase species abundance and diversity. Additionally, promoting and preserving habitat connectivity throughout the urban forest could increase the bird biodiversity, since it closes gaps between urban forest regions and establishes new habitats for various bird communities. Thus, implementing policies or plans that could reduce the overall human disturbance and increase the total habitat connectivity within an urban forest is key to maintaining or multiplying the overall bird biodiversity. This article established my understanding of how bird communities in urban environments are highly impacted by human disturbances, habitat structure, and habitat connectivity.

Apfelbeck, B., Snep, R. P., Hauck, T. E., Ferguson, J., Holy, M., Jakoby, C., & Weisser, W. W. (2020). Designing wildlife-inclusive cities that support human-animal co-existence. *Landscape and Urban Planning*, *200*, 103817.

With the increasing urbanization of cities around the world, planners and decision-makers have often begun to inadequately consider the ecosystem services that wildlife provides. Wildlife experiences within cities also promote the support of biodiversity conservation within urban areas. Typically, the roles within this process fall to planners, landscape architects, architects, and engineers. Integrating environmentalists, ecologists, and wildlife biologists into the initial planning concept discussions will promote the inclusion of wildlife biodiversity within the planning process. An effective way to impact wildlife biodiversity is to include wildlife zoning approaches and integrate conservation and enhancement areas within urban settings. After reading the article, the reader can make the assessment that the practice of integrating interdisciplinary design teams, the consideration of the life cycle of the target species in the design area, an active post-occupancy phase, and stakeholder involvement within the planning

process are all important steps planning and design teams should follow to adequately support the integration of wildlife biodiversity and health into urban environments. As a landscape architecture student, I find this article to be very thought-provoking and insightful into the issue of wildlife in urban areas and will provoke me to find solutions in my future work.

Associated Challenges:

Jim, C. Y., Konijnendijk van den Bosch, C., & Chen, W. Y. (2018). Acute challenges and solutions for urban forestry in compact and densifying cities. *Journal of Urban Planning and Development*, *144*(3), 04018025.

The article discusses various challenges that our urban forests are facing and offers some helpful insights on what we can try to do to better adapt our urban forests as cities become even denser. The authors broke the challenges down into 3 groups: (1) spatial-subaerial, (2) subterranean-root, and (3) institutional and social. The first category, spatial-subaerial, looks at the challenges above ground associated with urban forests. Specifically, the authors discussed how there is often insufficient space in our urban environment for the crowns and trunks of trees to properly mature. Trees are often planted in small plots in areas where there are significant amounts of impervious surfaces such as concrete that restrict trunk growth and they are also planted close to buildings or other trees that limit their canopy spread. As cities become more urbanized, the green vegetative spaces the trees need to fully mature are often replaced by more impervious surfaces that further restrict where more trees can be planted and limit the space for existing trees. The second category, subterranean-root, discusses below ground issues such as space for root growth and soil chemistry concerns. Highly urban soils can often be contaminated by buried construction materials (like concrete) which can slowly break down and raise the pH levels of the soil. When soil pH gets too high certain vital nutrients become unavailable causing a decline in tree health. Because of our sidewalks and roadways, the amount of space the tree roots have

available to spread is limited which can inhibit growth and be detrimental to the integrity of the tree itself. Dense urban areas often tend to have a high water table which limits the depth the roots can go. Often roots have to compete with underground utilities for space and suffer from damage to their root systems when these utilities need maintenance which invites fungus and disease to harm the health of the trees. The final group, institutional and social, focuses on issues that are less natural and have more to do with people and local governments. The authors specifically mention how outdated zoning laws have made some urban forest plantings difficult and how a lack of proper education among the public and even among professions has led to improper management of our urban forests. They also discussed safety concerns with expanding urban forests and the need to properly maintain our trees to reduce the risk of them falling and striking someone or something.

Steenberg, J. W. N., Millward, A. A., Nowak, D. J., & Robinson, P. J. (2017). A conceptual framework of urban forest ecosystem vulnerability. *Environmental Reviews, 25*(1), 115–126.

In this article, researchers identified exposure, sensitivity, and adaptive capacity as elements that organize the way we can understand vulnerability and organize a framework when thinking about the vulnerability of a social-ecological system as it relates to urban forestry. Exposure relates to the types and extents of stressors that affect urban forest systems in a negative way, which include the built environment, biological stressors, social stressors, soils, and the climate. Sensitivity is characterized as the response of the urban forest system as it relates to the magnitude of exposure. Some potential indicators of sensitivity are the structure, composition, and condition of specimens within the urban forest system. The adaptive capacity of a social-ecological system is defined as its capability to adapt to its conditions and function while stressed. This examines the social and environmental indicators tied to adaptive capacity that impact the social-ecological system. To quantify the impacts on ecosystem services through this

framework, the most effective forms of communication are through the use and description of indicators, aggregated indices, and prediction through forward-looking modeling, and mapping of these impacts. An assessment can be made that this kind of framework can benefit decision-makers and help them better understand the players that impact the social-ecological system of the urban forest. As a landscape architecture major that may have a role in planning projects, this research provides a valid framework for evaluating this issue and considering solutions.

Escobedo, Francisco J., Timm Kroeger, and John E. Wagner. "Urban forests and pollution mitigation: Analyzing ecosystem services and disservices." *Environmental pollution* 159.8-9 (2011): 2078-2087.

This paper brings multiple studies together to look at broad services and disservices that are created by urban forests. Many of the services mentioned are similar to others mentioned in other articles in this literature review. These services include but are not limited to pollution regulation, recreation opportunities, and health improvement. This paper is unique from the others in that it also evaluates some of the disservices that are caused by creating these green spaces. By increasing the number of trees in our urban spaces we are also increasing the number of airborne allergens. There is also significant maintenance that is required to keep up with our green spaces to make sure they remain healthy and hazard-free. Large trees can also be a nuisance by blocking views. Trees are often viewed as a benefit to natural aesthetics but perspective is everything and once trees reach maturity they can block out views that individuals may have previously enjoyed creating conflict. Green spaces also encourage wildlife to move into our urban spaces which can have benefits but also creates human-wildlife conflict from property destruction or issues with wildlife attacking pets. On top of this, having wildlife closer to people also causes the spread of certain diseases such as Lyme disease, West Nile virus, and rabies virus. There are also environmental concerns from creating these green spaces as it can result in invasive species encroachment if improper species are used or other issues such as

monoculture allow for species such as the emerald ash borer to spread significantly farther than they would have been able to without the assistance of the urban forests. While the urban forest provides many benefits for the urban population, it is important to weigh the potential issues that can be created when establishing new green spaces.

Author Index:

Apfelbeck, B., Snep, R. P., Hauck, T. E., Ferguson, J., Holy, M., Jakoby, C., ... & Weisser, W. W. (2020). Designing wildlife-inclusive cities that support human-animal co-existence. *Landscape and Urban Planning*, *200*, 103817.

Baró, F., Chaparro, L., Gómez-Baggethun, E., Langemeyer, J., Nowak, D. J., & Terradas, J. (2014). Contribution of Ecosystem Services to Air Quality and Climate Change Mitigation Policies: The Case of Urban Forests in Barcelona, Spain. *Ambio*, *43*(4), 466–479.

Bolund, Per, and Sven Hunhammar. "Ecosystem services in urban areas." *Ecological Economics* 29.2 (1999): 293-301.

Escobedo, Francisco J., Timm Kroeger, and John E. Wagner. "Urban forests and pollution mitigation: Analyzing ecosystem services and disservices." *Environmental pollution* 159.8-9 (2011): 2078-2087.

Fidino, Mason A., Elizabeth W. Lehrer, and Seth B. Magle. "Habitat dynamics of the Virginia opossum in a highly urban landscape." *The American Midland Naturalist* 175.2 (2016): 155-167.

Frantzeskaki, N., McPhearson, T., Collier, M. J., Kendal, D., Bulkeley, H., Dumitru, A., ... & Pintér, L. (2019). Nature-based solutions for urban climate change adaptation: linking science, policy, and practice communities for evidence-based decision-making. *BioScience*, *69*(6), 455-466.

Grima, N., Corcoran, W., Hill-James, C., Langton, B., Sommer, H., & Fisher, B. (2020). The importance of urban natural areas and urban ecosystem services during the COVID-19 pandemic. *PloS one*,*15*(12), e0243344.

Jim, C. Y., Konijnendijk van den Bosch, C., & Chen, W. Y. (2018). Acute challenges and solutions for urban forestry in compact and densifying cities. *Journal of Urban Planning and Development*, *144*(3), 04018025.

Jim, Chi Yung, and Wendy Y. Chen. "Ecosystem services and valuation of urban forests in China." *Cities* 26.4 (2009): 187-194.

Kang, W., Minor, E. S., Park, C. R., & Lee, D. (2015). Effects of habitat structure, human disturbance, and habitat connectivity on urban forest bird communities. *Urban ecosystems*, *18*(3), 857-870.

Kilpatrick, H. J., & Walter, W. D. (1997). Urban Deer Management: A Community Vote. *Wildlife Society Bulletin (1973-2006)*, *25*(2), 388–391.

Kuehler, E., Hathaway, J., & Tirpak, A. (2017). Quantifying the benefits of urban forest systems as a component of the green infrastructure stormwater treatment network. *Ecohydrology*, *10*(3), e1813.

Livesley, S. J., McPherson, E. G., & Calfapietra, C. (2016). The urban forest and ecosystem services: impact on urban water, heat, and pollution cycles at the tree, street, and city scale. *Journal of Environmental Quality. 45: 119-124*, *45*, 119-124.

Manes, F., Incerti, G., Salvatori, E., Vitale, M., Ricotta, C., & Costanza, R. (2012). Urban ecosystem services: tree diversity and stability of tropospheric ozone removal. *Ecological Applications*, *22*(1), 349–360.

Nesbitt, Lorien, et al. "The social and economic value of cultural ecosystem services provided by urban forests in North America: A review and suggestions for future research." *Urban Forestry & Urban Greening* 25 (2017): 103-111.

Nowak, D. J. (1993). Atmospheric carbon reduction by urban trees. *Journal of environmental management*, *37*(3), 207-217.

Nowak, D. J., Hirabayashi, S., Doyle, M., McGovern, M., & Pasher, J. (2018). Air pollution removal by urban forests in Canada and its effect on air quality and human health. *Urban Forestry & Urban Greening*, *29*, 40-48.

Raskin, E. (2015). Urban Forests as Weapons Against Climate Change: Lessons From California's Global Warming Solutions Act. *The Urban Lawyer*, *47*(3), 387–418.

Seitz, J., & Escobedo, F. (2008). Urban forests in Florida: Trees control stormwater runoff and improve water quality. *EDIS*, *2008*(5).

Steenberg, J. W. N., Millward, A. A., Nowak, D. J., & Robinson, P. J. (2017). A conceptual framework of urban forest ecosystem vulnerability. *Environmental Reviews*, *25*(1), 115–126.

Wang, Y., Chang, Q., & Li, X. (2021). Promoting sustainable carbon sequestration of plants in urban greenspace by planting design: A case study in parks of Beijing. *Urban Forestry & Urban Greening*, *64*, 127291.

Zellmer, A. J., Wood, E. M., Surasinghe, T., Putman, B. J., Pauly, G. B., Magle, S. B., ... & Fidino, M. (2020). What can we learn from wildlife sightings during the COVID-19 global shutdown?. *Ecosphere*, *11*(8), e03215.

Topic 4: Value of Urban Forests

Theme 1: Ethnobotany

Theme 2: Citizen science

Theme 3: Public/private partnerships

Theme 4: Real estate/property values

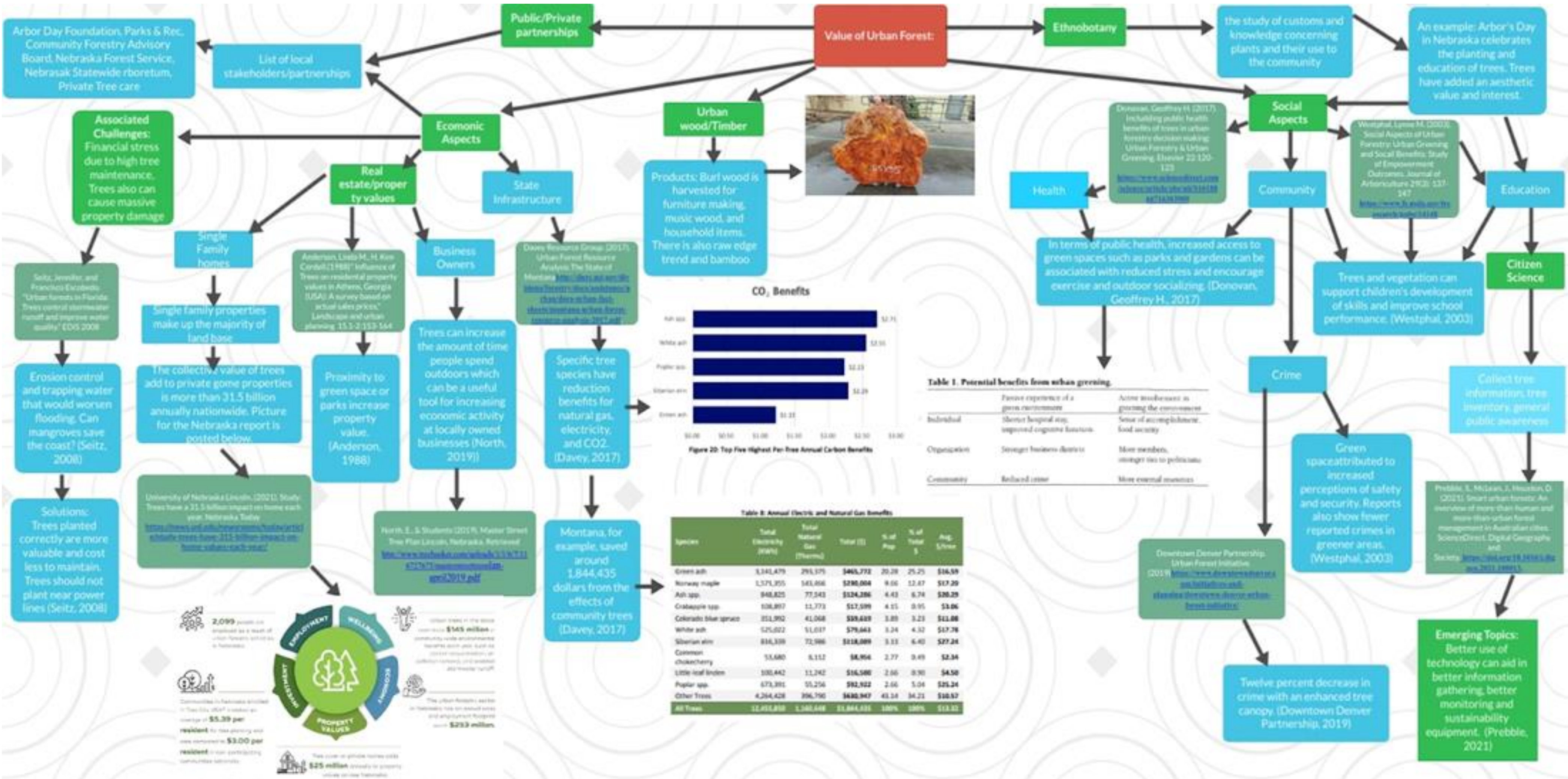
Theme 5: Social and economic aspects

Theme 6: Urban wood/non wood (timber) products

Theme 7: Wildland-Urban interface

Theme 8: Associated challenges

Theme 9: Emerging topics


Value of Urban Forest:
Public/Private partnerships
List of local stakeholders/partnerships
Arbor Day Foundation, Parks & Rec, Community Forestry Advisory Board, Nebraska Forest Service, Nebrasak Statewide rboretum, Private Tree care
Ecomonic Aspects
Associated Challenges: Financial stress due to high tree maintenance. Trees also can cause massive property damage
Seitz, Jennifer, and Francisco Escobedo. "Urban forests in Florida: Trees control stormwater runoff and improve water quality" EDIS 2008
Erosion control and trapping water that would worsen flooding. Can mangroves save the coast? (Seitz, 2008)
Solutions: Trees planted correctly are more valuable and cost less to maintain. Trees should not plant near power lines (Seitz, 2008)
Real estate/property values
Single Family homes
Single family properties make up the majority of land base
The collective value of trees add to private gome properties is more than 31.5 billion annually nationwide. Picture for the Nebraska report is posted below.
University of Nebraska Lincoln. (2021). Study: Trees have a 31.5 billion impact on home each year. Nebraska Today
Anderson, Linda M., H. Ken Cordell (1988) "Influence of Trees on residential property values in Athens, Georgia (USA): A survey based on actual sales prices." Landscape and urban planning 15.1-2:153-164
Proximity to green space or parks increase property value. (Anderson, 1988)
Business Owners
Trees can increase the amount of time people spend outdoors which can be a useful tool for increasing economic activity at locally owned businesses (North, 2019))
North, E., & Students (2019). Master Street Tree Plan Lincoln, Nebraska. Retrieved
State Infrastructure
Davey Resource Group. (2017). Urban Forest Resource Analysis The State of Montana
Specific tree species have reduction benefits for natural gas, electricity, and CO2. (Davey, 2017)
Montana, for example, saved around 1,844,435 dollars from the effects of community trees (Davey, 2017)
EMPLOYMENT
WELLBEING
ECONOMIC
PROPERTY VALUES
INVESTMENT
$145 million
$5.39 per resident
$3.00 per resident
$253 million
$25 million
Urban wood/Timber
Products: Burl wood is harvested for furniture making, music wood, and household items. There is also raw edge trend and bamboo
CO₂ Benefits
Figure 20: Top Five Highest Per-Tree Annual Carbon Benefits
Table 8: Annual Electric and Natural Gas Benefits
Ethnobotany
the study of customs and knowledge concerning plants and their use to the community
An example: Arbor's Day in Nebraska celebrates the planting and education of trees. Trees have added an aesthetic value and interest.
Social Aspects
Donovan, Geoffrey H. (2017). Including public health benefits of trees in urban forestry decision making. Urban Forestry & Urban Greening, Elsevier 22:120-123
Health
In terms of public health, increased access to green spaces such as parks and gardens can be associated with reduced stress and encourage exercise and outdoor socializing. (Donovan, Geoffrey H., 2017)
Table 1. Potential benefits from urban greening.
Community
Crime
Green spaceattributed to increased perceptions of safety and security. Reports also show fewer reported crimes in greener areas. (Westphal, 2003)
Downtown Denver Partnership. Urban Forest Initiative (2019)
Twelve percent decrease in crime with an enhanced tree canopy. (Downtown Denver Partnership, 2019)
Westphal, Lynne M. (2003). Social Aspects of Urban Forestry: Urban Greening and Socail Benefits: Study of Empowerment Outcomes. Journal of Arboriculture 29(3): 137-147
Trees and vegetation can support children's development of skills and improve school performance. (Westphal, 2003)
Education
Citizen Science
Collect tree information, tree inventory, general public awareness
Prebble, S., McLean, J., Houston, D. (2021). Smart urban forests: An overview of more-than-human and more-than-urban forest management in Australian cities. ScienceDirect. Digital Geography and Society.
Emerging Topics: Better use of technology can aid in better information gathering, better monitoring and sustainability equipment. (Prebble, 2021)

Ethnobotany

Messimer, J., Maynard, S., & Loveless, G. (2020, December 11). The Happiest People in America Live in This City. Men's Health. https://www.menshealth.com/health/a34919033/happiest-cities-in-america/

"Men's Health researchers ran data, from surveys about physical and mental health to statistics about financial and general well-being, on the residents of 100 of the largest cities in the U.S. Well-being (based on predictive Twitter language) and mental health (rates of depression, suicides, and mental-health status) made up 20 percent each in the weighted rankings. These factors each carried 15 percent: community (local organization engagement), financial well-being (employment, income equality, home ownership, and access to adequate housing), environment (park and traffic proximity), and physical health (including activity levels, obesity, and sleep)." "Star City didn't top any one category—it scored high in nearly all of them. Which is true happiness: balance. Lincoln did rank very high in park access, due to its 6,000- plus acres of land devoted to 132 parks, 134 miles of trails, nine public pools, and five city golf courses. Spending at least 120 minutes weekly in nature is linked to improved well-being, a 2019 Scientific Reports study found."

Citizen Science

University of Nebraska - Lincoln. (2020, February 17) *Calling all Tree Huskers: New forestry major approved*. News.unl.edu. Retrieved April 28, 2022, from https://news.unl.edu/newsrooms/today/article/calling-all-tree-huskers-new-forestry-major-approved/#:~:text=With%20the%20unanimous%20vote%20by

The University of Nebraska recently implemented a four-year Urban Forestry undergraduate degree program in partnership with the United States Forest Service, the Nebraska Forest Service and the Nebraska Statewide Arboretum, upgrading that program from previously only being available to students as a minor. Nebraska likely did this in an effort to maintain authority in the world of trees, seeing as we established Arbor Day. For people wanting to be Certified Arborists, is it just another bureaucratic gateway that's not necessary, considering arborism is a blue-collar trade? Certainly, academic education is relevant for foresters and biology. Is going beyond a minor worth the debt for an arborist? Would time be better spent on the job as an apprentice to a practicing arborist if you want to be an arborist yourself?

Trees for Energy. (n.d.). *What is the difference between arboriculture and urban forestry? – Trees for Energy Conservation*. Trees-Energy-Conservation.extension.org. Retrieved April 28, 2022, from https://trees-energy-conservation.extension.org/what-is-the-difference-between-arboriculture-an

Arborists and their science are tasked with the care of individual trees, while urban forestry involves trees as systems, or groups of trees in a built setting. Arborists are on the front line focusing on proper tree pruning, proper planting, proper rigging and climbing, fertilizing, watering, and disease mitigation, as well as other maintenance issues of overall individual tree health. Even among arborists, there is a difference in the expertise of climbing the tree and rigging versus making cuts from a bucket truck. Crane work expertise for very large trees or dead unclimbable trees becomes a necessary skill for some arborists to have as well. With Urban Foresters, Tree Energy Conservation Extension says "Urban forestry is also a social science, as well as incorporating the forest, and includes landscape level management such as urban forest inventory, valuation, planning, policy, etc. The two fields certainly overlap, but the training and

practice of both are unique." Urban Forestry's city-wide scale and involvement of social science and policy definitely makes room for having an academic background.

Trees cannot be trimmed by bots, and sometimes bucket trucks cannot even get to certain places, so it seems arborism will always be a human profession.

Lincoln Parks & Recreation. (n.d.). Arborist Examination Study Guide

All you need to be a Certified Arborist is a local arborist license obtained through taking a Lincoln Parks and Recreation test, and insurance to work on your own as an arborist in Nebraska. There is an emphasis on work as an apprentice, as study guides can't teach you hands-on or all that can go wrong. Ground workers are covered by the insurance of who they contract under, and that's how most people start their arborist apprenticeships under a climber. Additionally, elevating to a Plant Health certification is another additional Lincoln Parks and Recreation test. One can become further certified by the International Society of Arboriculture without a degree. Regular Licensed Arborists can do certain foliar treatment sprays without the additional Plant Health license too. That is especially good when it is all hands-on deck for preventing Ash extinction.

American Arborists (2018, February 18). *Three Jobs Surprisingly Less Dangerous Than an Arborist.* From https://www.americanarborists.net/tree-tips/2018/february/three-jobs-surprisingly-less-dangerous-than-an-a/

Arborist Safety: Nebraska has some pretty large trees compared to some other states. People may think of Oregon when they think of large trees, but Ponderosa Pines are sometimes like climbing a ladder. Nebraska's state tree is the Cottonwood, and the wide canopied trees of Nebraska require multiple rigging points and walking out horizontally on limbs. Making arborists feel safer

when they are literally putting their life on the climb line becomes important in such a tree-oriented city such as Lincoln. To include insight from demographic and exigency standpoints, it is interesting that there's an idea that people doing hard or dangerous jobs are doing so because they don't want to or could not further their studies, and therefore have no other job options. Arborism is one of the most dangerous jobs a person can have. Arborists are at the mercy of gravity and physics on an extreme scale. They are sometimes in more danger than power-line workers, seeing as arborists sometimes come closer to power lines when in a tree and the current can arc over to them. Arborists are also sometimes in more danger than roofers because of decaying wood (American Arborists, 2018). The researchers backing up the idea that blue collar workers are less skilled than white collar workers are often white-collar people themselves, so they are biased toward maintaining their status. Arborists learn their knowledge from studying a textbook and supplementing it with knowledge they acquire in the field.

International Society of Arboriculture. (n.d.). International Tree Climbing Championship Aerial Rescue Event. Retrieved April 28, 2022, from https://www.itcc-isa.com/Portals/0/docs/about_Eventdescriptions_AerialRescue.pdf

Arborists do all they can to make tree care safe for both worker and customer, so cities must make sure there is always reciprocated regard for arborist safety. Aerial rescue demonstrations come into play here. Climbing arborists can make mistakes, such as cutting the branch they were tied into and falling, or decay was not viable and broke out. Sometimes unlicensed and uninformed climbers slip through the cracks. Climbers can even have a heart attack or heat stroke while happening to be up in a tree. Arborists sometimes get stuck, needing to be rescued. Fire rescue crews and first responders usually try to keep people away from the scene because they don't want interference in their own exclusive operations, but other arborists can often

access the fallen climber more easily and quickly because the first responders don't have adequate climbing rescue solutions. Another climber could even get the injured climber down before first responders arrive. Arborists should also have an extra climb line placed in the tree they're working in so that another person may ascend the tree quickly if necessary.

TreeStuff. *Tree-o-Cache*. (n.d.). www.treestuff.com. Retrieved April 28, 2022, from https://www.treestuff.com/tree-o-cache

Educational Events: Recreational climbs put on by arborists can generate interest in trees and climbing them. Tree-o-caches are a fun way to get people involved with trees and tree climbing. The idea is similar to geocaching, where a person gets a set of coordinates and goes out to find the cache located at the point. In the cache you'll find a written log of everyone's name who has found it, and you yourself leave an object in the collection bin when you find it. For a tree-o-cache, this would be a set of coordinates to a tree, and then a climb up to the collection bin in the canopy. Tree-o-caches should be in trees with just one primary stem, or a canopy that can only be accessed with a throw ball, rope, and climbing saddle… i.e., not easily free climbed from ground to avoid injury. These would function as points of interest to get people interested in tree climbing. The better arborists the city has, the better community trees we have. There is already one tree-o-cache in a large specimen Cottonwood tree in the expansive and forested Wilderness Park in South Lincoln. For the existing cache, coordinates can be acquired by contacting TreeStuff.com, an arborist supply store and educator. Citizens can submit their own cache coordinates to TreeStuff as well if Lincoln or the Arbor Day Foundation don't take on their own cache efforts.

Timber Products

Beals, H.O.; Davis, T.C. (1977, January) Figure in wood - an illustrated review. *Alabama Agricultural Experiment Station, Auburn University: Auburn Alabama*, Bulletin No. 486, 15-16

"Burls are irregular, spherical growths that occasionally occur on trees near ground level (24, 53). They occur primarily on elm, walnut, maple, and redwood. Rarely do they occur commercially in other trees. Many of the most prized possessions of early emperors and kings were made from burl wood (53). Utilization of elm burls for furniture in the U.S. during the 1920's probably led to introduction of Dutch elm disease into this country. Ceratocystis ulmi (causal fungus of Dutch elm disease) probably was introduced into this country within elm-burl material imported from France for use as veneer and subsequently in furniture manufacture. Burls are usually small and characterized by eye-like markings surrounded by swirls and distorted tissues. Burl tissue is soft and "velvet-like" to the touch"

NPR. (2021, July 8). *What The Rise and Fall of Lumber Prices Tell Us About the Pandemic Economy*. NPR.org. https://www.npr.org/2021/07/08/1013819703/what-the-rise-and-fall-of-lumber-prices-tell-us-about-the-pandemic-economy

Most of the markup of lumber was from sawmills, as there wasn't a shortage of trees. "Lumber still costs about 80% more now than it did before the pandemic - a premium that builders say is adding tens of thousands of dollars to the price of a new home." The article also notes that when lumber prices do fall, like prices did after the pandemic, it was because people were trying to get out of the house, so the only wood they were buying was for outdoor decking.

Xu, QF., Jiang, PK., Wu, JS. et al. (2015.) Bamboo invasion of native broadleaf forest modified soil microbial communities and diversity. Biol Invasions 17, 433–444. https://doi.org/10.1007/s10530-014-0741-y

"Moso bamboo (Phyllostachys edulis) invasion of native forests in Tianmushan National Nature Reserve located in southeastern China has resulted in greatly decreased biodiversity of plants and birds." Bamboo is not better for making toilet paper and other paper products because it does not provide habitat and is invasive. Setting aside trees for paper farming while making sure carbon is still being sequestered is a better option.

Nebraska Forest Service (n.d.) *Windbreaks | Nebraska Forest Service*. Nfs.unl.edu. Retrieved April 28, 2022, from https://nfs.unl.edu/publication-type/windbreaks

Windbreak trees become relevant for protecting crops from the hefty gusts of the windswept plains. Nebraska has been reported to be even windier lately. Windbreaks are a way of utilizing hills that cannot be planted out with crops.

The Nature Conservancy. (2019, December 2) Real vs Fake Christmas Tree. Www.nature.org. https://www.nature.org/en-us/what-we-do/our-priorities/protect-water-and-land/land-and-water-stories/real-vs-fake-christmas-tree/

Humans need to do the math when determining whether to get a fake or real tree for Christmas. If they use the plastic tree long enough, it may have less of a footprint, but not if they throw it out too soon.

Social and economic vales of urban forests

The Near South Neighborhood Association. (2022) *"The Near South*." Retrieved April 28, 2022, from https://nearsouth.org

The Near South Neighborhood recently achieved a 100% on American Forests' Tree Equity Score. According to American Forests, "Tree Equity is a metric helping cities assess how well they deliver equitable tree canopy cover to all residents. The score combines measures of tree canopy cover need and priority for trees in urban neighborhoods. It is derived from tree canopy cover, climate, demographic, and socioeconomic data." Near South has 40% canopy cover. The only area that has more canopy cover based on satellite view is Sheridan Boulevard. Sheridan had race restrictions stipulating only "those of Caucasian race" could buy homes when developed by Woods Brothers, lowering their score. The Near South Neighborhood Association is celebrating their 50th anniversary along with the Arbor Day Foundation. Near South is the most historic, diverse, populated, and condensed neighborhood in Lincoln. So, when trees are managed in the area, it likely impacts the most people that it could have. Urban density is essential to maintaining greenspace for future generations. Otis, the man who invented the elevator that enabled us to build upwards, may be the most underrated conservationist of all time. The Near South has had its fair share of somewhat "green" efforts in the past. Near South saw the addition of slip-in style apartments in the midcentury. Owners of older historic homes sold their large lots then because property taxes weren't affordable, so brick apartment buildings were built between homes allowing for more density. Near South has about reached infill capacity, so their next endeavor could possibly be arboretum related. The Near South Neighborhood Association is a successful grassroots organization (not an HOA) advocating for the inherent sustainability of historic home preservation, for our residents, and for protecting the abundant greenspace in Near South. The NSNA interacts with Lincoln City Council regularly, as well as

the City Attorney, Planning Director, retired Historic Preservation Planner Ed Zimmer, and Building & Safety. The Board includes realtors, engineers, neighbors, students, professors, lawyers, and the Mayor's current Planning and Urban Development Aide, who is the former Lincoln-Lancaster County Planning Commissioner. Near South has its own Parks Committee that advocates for financial grants to support initiatives like park renovation plans, specifically for Peach Park currently. Picnic shelters will be added, the basketball court will be moved, playground equipment installed, broken drinking fountain replaced, and of course trees will be planted. Other notable Near South parks include Sunken Gardens, Hazel Abel, Prescott Park and Near South Park. Near South's Parks Committee coordinates contracts with Lincoln Parks & Recreation, Lincoln Parks Foundation. Near South does their Tour of Homes for Mother's Day, where a handful of residents open their homes for open houses. During the pandemic, Near South did a backyard tour and they are considering keeping the event. This backyard tour or impromptu "Tree Tour" included historic specimen trees to illustrate what people can expect during the life of their own trees.

Tree Equity Score. (n.d.). American Forests. Retrieved April 28, 2022, from https://www.americanforests.org/tools-research-reports-and-guides/tree-equity-score/

"Tree Equity is a metric helping cities assess how well they deliver equitable tree canopy cover to all residents. The score combines measures of tree canopy cover need and priority for trees in urban neighborhoods. It is derived from tree canopy cover, climate, demographic, and socioeconomic data." It is hotter in lower income neighborhoods and there is less greenspace. Tree diversity (species, age, and size) suffers in lower income neighborhoods. Maintenance is also less prioritized in lower income areas. There are more power lines in interior or older neighborhoods. The ten foot "clearance not appearance" motto that power line clearance

companies use can make for some ugly neighborhood trees, though it is oftentimes a free trim for homeowners. Aesthetics could stand to be valued more in that situation. Nurseries should have variety, not just what people ask for like Maple or Oak, as good as they are. Lincoln, Nebraska's Master Street Tree Plan (219) mentions "incorporating intentional efforts to increase tree diversity and achieve maximum representation of tree variety within the city of Lincoln." For equity, Lincoln Parks & Recreation could perform and/or subsidize tree maintenance in areas that don't prioritize it. The grants they introduced for dead tree removal on private property should help with this.

Cowett, F. D., & Bassuk, N. (2017). Street Tree Diversity in Three Northeastern U.S. States. Arboriculture & Urban Forestry, 43(1). https://doi.org/10.48044/jauf.2017.001

New York, New Jersey, and Pennsylvania were studied for tree diversity. Biodiversity in general is associated with stability and productivity of non-urban vegetative ecosystems. Planting one kind of tree, like just Elm, Ash, or Maple, can be damaging because all the trees can be wiped out by disease in the absence of other species, like Asian Horn Beetles in Maples. Urban forests endure factors that wild forests don't, like urban heat islands, little water infiltration or on the other hand, flooding. Also, impermeable surfaces, compacted and nutrient deficient anthropogenic soil, and pollution. In this study, there is a lack of tree diversity on the regional, statewide, and municipal levels in all three states. This limits the available selection of trees since the tree species have to be adaptable to urban stressors. Many other issues may limit tree selection, such as less prevalent street tree species and genera being unavailable from local suppliers. People buying from nurseries only ask about familiar trees. Many of these challenges can be migrated, but municipal budgets can be limited. This would be easier to supplement in a city with less established trees.

“One common metric employed to assess street tree diversity is frequency distribution, where the relative abundances of street trees belonging to botanic species, genera, and families are calculated as percentages of the population as a whole.” “Species diversity is correlated more with the number of species than with evenness in the species distribution. For Shannon-Wiener Diversity Index, although not for the Inverse SDI, genus diversity is correlated more with the number of genera than with the evenness of genera distribution.”

Santamour’s 10-20-30 benchmark says that ideally no tree species should comprise more than 10 percent, and no tree genus should comprise more than 20 percent of total trees in the area. No tree family should be more than 30 percent of the total trees in the area. Sanders (1981) found Norway maple (Acer) to comprise 37.5% of all street trees in Syracuse, New York, U.S.; Lesser (1996) found American sweetgum (Liquidambar styraciflua) to comprise 14.27% of all street trees in 21 southern California cities; and Ball et al. (2007) found ashes (Fraxinus spp.) to comprise 36.3% of all street trees in 34 South Dakota communities. Some say that 10-20-30 doesn’t apply because some species are well adapted or native to an area and should be abundant. On other hand, some have taken the recommended percentage down to just 5% of a species or genus allowed. Santamour advocates tree distribution evenness over species richness.

McPherson and Rowntree (1989) and Pauleit (2002) found greater street tree diversity to be associated with warmer climate, Jim and Chen (2009) found greater street tree diversity in older neighborhoods, and Kara (2012) found differences in street tree diversity based on land use and street type. The areas used were census zones that were populated, including more rural unincorporated towns that still have street trees. The sample may not exactly be random, but they correct for that.

Street tree diversity was found to be greatest in New Jersey and least in New York State. Street tree diversity increased as the minimum average winter temperature increased. Avg minimum winter temperature increases in species and genus diversity for the Inverse SDI and Shannon-Wiener Diversity Index were found to correspond with temperature increases in the 2012 USDA Plant Hardiness Zones.

Acer platanoides (Norway maple) was found to be the most prevalent street tree species in all three states, with a regional mean of 16.34%... (14.63% in New Jersey, 19.80% in New York, and 15.08% in Pennsylvania). Acer/Maple was found to be the most prevalent street tree genus in all three states, with a mean of 38.94% (36.72% in New Jersey, 40.91% in New York, and 38.96% in Pennsylvania). Maples were common, then came pear, oak, London planetree, and then types of locusts (gleditsia). All common trees people can easily remember by name and ask for at nurseries. Diversity in age, size, and species are important.

Increased street tree diversity was associated more with a greater number of less abundant species and genera than with more even distributions or street tree population size. Obviously when Maple numbers increase, street tree diversity decreases. Some trees aren't good street trees, and some streets aren't good for trees. Weak wooded maples, not enough variety in age so they all mature and die at the same time, leaving barrenness.

North, E., & Students. (2019, April). *Master Street Tree Plan Lincoln, Nebraska*. Retrieved April 28, 2022, from http://www.treehusker.com/uploads/1/1/6/7/116727675/masterstreettreeplan-april2019.pdf

In 2019, Lincoln's own (approximately) 120,000 public trees were determined to provide the community with nearly $12 million in benefits. The Master Street Tree Plan mentions that well-kept greenery and trees can increase the amount of time people spend outdoors, which can be a good tool for increasing economic activity at locally owned businesses.

Seitz, Jennifer, and Francisco Escobedo. (2008) "Urban forests in Florida: Trees control stormwater runoff and improve water quality." EDIS 2008.5

Trees provide erosion control, trapping water that would worsen flooding and therefore also the damage costs. Can mangroves save the coast? The expensive Mangrove roots can keep the sediment of sea banks together, preventing the rising tides from sweeping them away.

Nebraska Forest Service. (2019, August 19) *Top 10 Tree Planting Mistakes | Nebraska Forest Service*. Nfs.unl.edu. Retrieved April 28, 2022, from https://nfs.unl.edu/publications/top-10-tree-planting-mistakes

Trees should be planted correctly so the tree is more valuable and costs less to maintain. Some trees are planted in acidic soil that leads to chlorosis, or too deep which leads to stem girdling roots. A nursery may have kept the tree in a container too long. Trees planted in Tactical Urbanism or Vigilante Planting (unpermitted) attempts may have been planted in concrete areas where there is not enough water infiltration into the soil for the tree to survive. Trees should not be planted near power lines or where limbs can fall and damage the built environment.

Kellogg, W., Mikelbank, B., Laverne, R., & Hexter, K. (2017). The Economic Value of Tree Preservation in a Weak Land Development Market Region. Arboriculture & Urban Forestry, 43(2). https://doi.org/10.48044/jauf.2017.006

“The purpose of this study was to characterize the economic value gained from the preservation of mature trees during the land development process. The study focused on six counties constituting the greater Cleveland, Ohio, U.S., real estate and land development market. The research suggests that both economic and environmental value could be found by encouraging the development community to maintain trees (vs. removing) in the periphery of subdivisions and along water courses, such as riparian areas, streams, and wetlands. These practices would likely provide the most direct benefits to water resources, while enhancing the value of lots in subdivisions most significantly.”

Miller, R. W., Hauer, R. J., & Werner, L. P. (2015). Urban Forestry: Planning and Managing Urban Greenspaces. (3rd ed.) Waveland Press, Inc.

The textbook points out that funds for tree planting are generally easier to come by because tree planting is easy to understand. Planting trees produces immediate visual impact, and an agency can get recognition for doing the planting. Fund for maintenance may be harder for other street tree management activities with “minimal visual impact” undertaken by a city.

Lincoln Parks & Recreation. (n.d.). Arborist Examination Study Guide

Arborists are on the front lines when it comes to trees, so it is important to have good ones. The arborist should be sanitizing their tools regularly, like pole saws, chainsaws, and ropes. When trimming a tree, one is basically making an open wound on a living being as you make a cut. Fungus and disease can enter the tree more easily this way, so sanitization is important to prevent this. Oak trees must be trimmed during dormant winter months because they are so susceptible to fungus entering their system while they are active. Hiring a Certified Arborist is important because they know this and won’t jeopardize the tree's health. Spikes should also be sanitized if

being used at all. Spikes are boot attachments that have a pointed talon on the inside ankle so that the climber can climb the tree by stabbing their feet into the trunk to stand upright while they make a cut. Spikes should not be used on live trees, they are only to be used in removals, cutting down trunks when no tree limbs to rig a rope onto are left, when introducing disease doesn't matter if the tree will be reduced to logs going in a chipper in a few hours. However, the disease that killed the tree that then had to be cut down could linger on the unsanitized spike and serve as a direct line to another tree's trunk, infecting another trim later. That being said, again, spikes should never be used to ascend living trees, as it is unnecessary damage that can weaken the tree. The tree should be cut from a bucket or climbed. Climbing is better for the environment as it involves rope and saddle, not a heavy duty 20ft bucket truck and the gas and emissions that come with it. Electric chainsaws have also recently become more advanced and could be used on smaller tree jobs, further reducing emissions and fuel use.

Healthy trees should also never be "topped," a damaging kind of trim where the leafing branches are cut to stubs, leaving the stump and some log leads coming off of it. The tree then tries to compensate rapidly, producing weak branches that grow straight up vertically and are more prone to breaking because of this. The tree is also not as healthy, as brush removal should not exceed 25 percent. "Lion tailing" should also be avoided.

The Tree Care Industry Association. (n.d.). Guidance for Crane Practices in Arboriculture. Retrieved April 28, 2022, from https://www.tcia.org/TCIAPdfs/Resources/Arboriculture/Technical/guidance-for-crane-practices-in-arboriculture-20120601.pdf

“OSHA’s issue with cranes in arboriculture focuses narrowly on the practice of hoisting a climber into a work position with the crane. This practice violates an OSHA standard, even though it may provide the safest or only feasible means to access a tree’s canopy, as it does in the illustration to the right. The burden of proof is on the arborist to establish that complying with OSHA’s standard is either impossible (infeasible) or less safe for workers.” When arborists are forced to do removals with a crane, it costs more because of equipment and the physical risk and bureaucratic OSHA risk.

Trees are much more costly to remove once they have been dead long enough to begin hollowing out. Climbing arborists usually use other limbs of the tree to attach rope and pulleys to so that the ground-worker can slowly guide and lower the large branches the climber cuts to the ground. Dead trees cannot support rope rigging without breaking and may not even allow for the climber's weight alone. Climbers do not want to climb trees that can’t support their weight, so the expensive cost of using a crane on the tree then gets factored into the removal if the tree is large. Trees break more easily the more dead they become as well, so that poses a risk. When a tree is determined to be on the outs, the earlier the better for removal.

Trees and their value as carbon sequesters relies heavily upon how well the trees are maintained. Again, trees are more costly to remove once they have been dead long enough to hollow out. This is because climbers won’t climb the tree anymore, and now a crane may be needed. A costly removal could have been put off if an at-risk branch was cut off with a saw before wind broke it off and stripped the bark all the way down the tree along with it, making the tree vulnerable to disease. There are a lot of possible scenarios illustrating how maintenance is a necessary cost to avoid further expenses.

NYC Parks. (n.d.). *Illegal Tree Work and Damage: NYC Parks*. www.nycgovparks.org. Retrieved April 28, 2022, from https://www.nycgovparks.org/services/forestry/illegal-tree-work#:~:text=Removing%20a%20tree%20without%20a

A provision that removing, killing, or damaging a street or park tree, whether intentionally or accidentally being a crime could be added, though very radical. NYC Parks does this, and "most violations are misdemeanors, punishable by a fine of up to $1,000 and/or imprisonment up to 90 days. Removing a tree without a permit and damaging trees are very serious offenses, punishable by a fine of up to $15,000 and/or imprisonment for up to one year. Anyone caught removing or otherwise harming a tree should be reported." The example picture is two large Pin Oaks with a trench dug between them. Again, a radical approach to funds and tree prioritization.

PROPOSAL: Every Log Has Its Day… Monitoring Tree Removal: In a somewhat radical attempt, when it comes to removing trees, companies should consider charging more for unnecessary removals of healthy trees. Some people want trees removed because they leave acorns, or they want a better view. Many tree services already charge extra for the removal of healthy trees, but of course they would not admit to it. Such a tax could serve to deter the removal of healthy trees. If it was a fine implemented by the city, it would work out more harmoniously because every tree company would abide by the fine or tax, and another tree service wouldn't come in and underbid a tree service that implements an extra charge for healthy removals in order to land the job. The city implementing the healthy removal fine would also be a way to invigorate the local tree worker economy if most of the tax profits went back into their pockets. Or the tax could find municipal tree management. The fine would also make it so private tree services have to present themselves to customers as having at least some regard for

the health of trees. This healthy tree removal fine would involve quite a bit of reporting when it comes to keeping track of tree removals, which is a large undertaking.

Lincoln Parks & Recreation. (n.d.). Arborist Examination Study Guide

Private tree services often offer free estimates that come with risk assessment by the arborist, and this can easily be utilized by those seeking care for their trees with a phone call. Said risk assessment also intersects with the importance of making sure a licensed and insured arborist is being hired to do or assess the job. Injury can easily result from doing tree work yourself and not hiring a professional. Additionally, if the uninsured tree worker is injured or breaks something on the property, the customer is left with the bill.

Going along with knowing when to cut down, sometimes tree services will try and sell plant health solutions to revive trees, such as iron injections for a Pin Oak tree with Oak Wilt fungus. Sometimes this can save a tree, but sometimes it can be another way to get extra money out of the customer even when the tree service knows the tree is beyond help.

PROPOSAL: The City of Lincoln could use their research university stature to provide online resources (or otherwise) for people curious about their tree's prognosis, or to remind people to get multiple bids and opinions from other licensed arborists. For example, Pin Oaks have primaries, one trunk that everything grows off of. The Oak tree may still be green and leafing out in other areas, but if the primary is dead, the whole tree is on its way out and nothing can be done. If another Pin Oak was proximate to the one that had the Oak wilt fungus, it usually means that both were infected. Sometimes though, if one infected tree is caught early enough and handled properly, disease won't spread as far.

Segue into Real Estate... There should be an incentive to sell trimming city byway trees when already working on property.

Real Estate & Property Values

Lincoln Parks & Recreation. Community Forestry: Adopt-an-Ash Program. (n.d.). www.lincoln.ne.gov. Retrieved April 28, 2022, from https://www.lincoln.ne.gov/City/Departments/Parks-and-Recreation/Community-Forestry#section-4

The Adopt an Ash program in Lincoln can save neighborhoods from having unsightly dead trees by treating them, preventing removal. Treatment would be less expensive than removal. This could save neighborhoods from having all their trees die at once, possibly lowering the value of the neighborhood since it is barren.

Property owners can "adopt" Ash street trees to fund regular chemical trunk treatments against Emerald Ash Borer, preventing removal. EAB has killed hundreds of millions of Ash trees in the U.S. since 2002. 14,000 Ash trees make up 12% of Lincoln's public trees.

Lincoln, Nebraska Master Street Tree Plan; 12.20.050 Issuance of Permit; Requirements Pertaining to Planting, Maintaining, Removal, and Destruction. (2022)

"After inspection of the location in question, if in his opinion it is desirable that such tree be planted, removed, or destroyed, the Director shall issue a permit therefor. Such permit shall set forth the name and address of the owner of the property abutting the public property upon which such work is to be done; the name and address of the person who will perform such work; and the location at which such work will be performed."

An incident between LTU and Lincoln Parks & Recreation with a historic Near South Pin Oak removal is an example of why at least communication of work being done is necessary. In March 2021, Raina Engelhard called Lincoln Parks & Recreation when a private tree company showed up to use the private driveway to remove a healthy Oak and said they were working for the city. However, the man in the bucket did not have a hard hat or fall arrest on, which the city would not tolerate. Unlicensed people can slip through the cracks working for licensed companies. Lincoln Transport and Utilities never informed Parks & Recreation that 5 large Oaks were coming down in the neighborhood. The tree could not be negotiated, as the plan was too far along, but there was a meeting with the City Council to discuss the issue. This is a disappointing lack of communication and safety, especially hired by the city, and it perpetuates reasons why the public may question funding for trees.

Dilley, J., Wolf, Kathleen L. (2013). Homeowner Interactions with Residential Trees in Urban Areas: International Society of Arboriculture. *Arboriculture & Urban Forestry 39(6): 267-277* .pnw_2013_dilley001.pdf (fs.fed.us)

There are several ways people interact with Urban Trees. Rather those interactions are done with pruning, and recreational activities like tree climbing, surveying, planting and managing; the behavior illustrates a connection between human dimensions and Urban Forestry. Human dimensions with trees often express themselves and different ways and on different scales. The authors use survey and respondent data to evaluate behaviors and perceptions that humans have of their local trees. This analysis is much needed since Single-Family properties currently make up the majority of the land base in most large cities which means collectively, they can have a major impact on the managing of trees. The value of this analysis is that encouraging certain behaviors for people to have concerning their Urban Forest can help strengthen communities,

manage Urban trees better, and provide the community with the tools to learn from. We strongly believe that is paper is an informative piece and can help in decision making.

University of Nebraska Lincoln. (2021). Study: Trees have a $31.5 billion impact on home values each year. Nebraska Today. https://news.unl.edu/newsrooms/today/article/study-trees-have-315-billion-impact-on-home-values-each-year/

This report illustrates that Urban forestry has a positive economic footprint for homeowners. The collective value of trees add to private home properties is more than 31.5 billion annually nationwide. According to the article, urban trees had the largest annual impact on the quality of life in Texas, Georgia, Florida, North Carolina, Mississippi, Alabama, Pennsylvania, California, Virginia, and Louisiana. This report also has a detailed analysis of every state. An interesting aspect that I thought is needed is why these states have seen such a positive impact. Many of these states are in the South so an assumption could be that a warmer climate could provide more suitable trees for an urban environment despite the climate also not being favorable to other Tree species. Furthermore, policies relating to homeowners can be complicated. Although, proximity to green spaces can increase property value. Perhaps, more homes are located near parks and gardens in the top ten states when compared to other states.

Westphal, Lynne M. (2003). Social Aspects of Urban Forestry: Urban Greening and Social Benefits: Study of Empowerment Outcomes. *Journal of Arboriculture 29(3):*137-147 https://www.fs.usda.gov/treesearch/pubs/14148

Urban forests can have an impact on critical social issues such as health care, education, crime and safety, economic development, and social disenfranchisement. Green areas provide beauty and aesthetics to Urban areas that can have an almost psychological effect on us. Evaluating the

effect of Urban Forest on each level, local and state level, provides an understanding of the forest's overall value to the social aspects of the space. The article goes into depth about how trees influence the impact of the social aspects of our society. We were surprised that there was any benefit that trees had on social empowerment, safety, and crime. The author of the study also specifies certain words like “Empowerment” in order to be more understood. The paper acknowledged that there are different usages for the same word like “Empowerment” which can mean a lot of different things but specifying the word clarifies the author’s intentions and narrows down measurable parameters. narrowing down a term into a fixed definition can miss a few potential problems about the subject. However, this does not seem to be the case in this paper.

Donovan, Geoffrey H. (2017). Including public-health benefits of trees in urban-forestry decision making: Urban Forestry & Urban Greening. Elsevier 22:120-123 https://www.sciencedirect.com/science/article/abs/pii/S1618866716303909

Public Health is an important aspect of any functioning society. Access to green spaces such as parks and gardens can be associated with reduced stress and encourage exercise and outdoor socializing. An increase in social connectivity can give local citizens an increased sense of community. Trees in urban environments must be planted and located in the best areas to absorb air pollution and provide needed cooling and shade in hot temperatures. This paper goes into great depth about the public health dynamics that urban forests have. Interestingly, the socioeconomic dynamics reveal that neighborhood walkability and the density of fast-food restaurants can impact health. This would make for an interesting commentary on America’s car-dependent culture and rather a healthier future requires tree-planting programs and green spaces to encourage outdoor socializing and exercise. Although, social benefits can be more difficult to

measure due to personal subjectivity and overemphasizing in the decision-making process. The public health aspects and policies of Urban forests must be considered when managing green spaces in future decision-making.

Davey Resource Group. (2017). Urban Forest Resource Analysis The State of Montana. http://dnrc.mt.gov/divisions/forestry/docs/assistance/urban/docs-urban-fact-sheets/montana-urban-forest-resource-analysis-2017.pdf

An overall assessment of Montana's Urban and community trees benefits. Investment in green areas can provide many economic benefits to states and local governments. Montana, for example, saved approximately 1,844,435 dollars from the effects of community trees. An important aspect when considering the value of a specific tree species is its reduction benefits for electricity and natural gas. Younger trees are at a disadvantage since their small stature means fewer reduction benefits. For example, the chokeberry (Prunus virginiana) provides $2.34 in average annual benefits and just provides just 0.5% of energy benefits. These energy benefits will increase as the younger trees mature but the initial investment may be too costly for some local governments. Obviously, planting trees at the right sites and careful management can offset costs. Although, an interesting aspect is Montana's management program which includes structural pruning and training of young trees. Replaceable seems mostly reserved for older mature trees. Montana's urban forests have done a remarkable job of reducing electric energy consumption and natural gas consumption. This report illustrates the benefits an urban forest can have statewide when managed properly.

Sohn, W., Kim, H. W., Kim, J.-H., & Li, M.-H. (2020). The capitalized amenity of green infrastructure in single-family housing values: An application of the spatial hedonic

pricing method. Urban Forestry and Urban Greening, Vol. 49. Retrieved from https://doi.org/10.1016/j.ufug.2020.126643

The benefits of, in combination, urban greenspaces and detention ponds can have a very drastic effect on housing values. As well as adding a park-like amenity to neighborhoods. This study is reliable because it is accessible through ScienceDirect, which is a multi-disciplinary, peer-reviewed journal article database. Mainly covering research in the fields of science, technology, medicine, social sciences, and humanities. This study adds to my previous knowledge on the value of greenspaces and other natural resources factor on housing value.

Jim, C. Y., Konijnendijk van den Bosch, C., & Chen, W. Y. (2018). Acute Challenges and Solutions for Urban Forestry in Compact and Densifying Cities. Journal of Urban Planning and Development, Vol. 144(3). Retrieved from https://ascelibrary.org/doi/full/10.1061/%28ASCE%29UP.1943-5444.0000466?casa_token=UN7zSuS4pMQAAAAA%3AzYl0FkwmTw6nWzIFeaU1AqN0XZN1qHuZQ0iAeWzstzP6Nj595RhLoI2CKU3VKkmMbwap1_WgQLTd

With increased demand for housing and dense urban environments, this tends to lead to less vegetation-growing spaces. This makes it much more difficult to find places for both traditional greenspaces and things such as just street trees. They break down this issue into three main sections: Spatial-subaerial, subterranean-roots, and institutional and social. They then go on to describe better ways to integrate greenspaces in more dense urban environments. This study is credible because it is a part of the ASCE Library, which is an online, full-text, civil engineering database providing the contents of peer-reviewed journals, proceedings, e-books, and standards published by the American Society of Civil Engineers. In addition to this, it was also published

in a sperate peer-reviewed journal. This study adds to my previous knowledge on the challenges of trying to fit in greenspaces into dense urban environments.

Kuo, F. E. (2003). Social Aspects of Urban Forestry: the Role of Arboriculture in a Healthy Social Ecology. Journal of Arboriculture, Vol. 29(3):148-155. Retrieved from https://www.nrs.fs.fed.us/pubs/3860

While the effects of arboriculture clearly contributes to the health of biological ecosystems, it is harder to draw conclusions as to if it contributes to the health of the social ecosystem as well. Some evidence from multiple studies in Chicago seem to make the link between the two. In residential areas that are seen as "barren", these areas are often seen as "no man's land". This tends to discourage resident interaction and invite more crime. It tended to be the opposite in areas that had a high tree presence and well-maintained grassy areas. This study is reliable because it published on the U.S. Forest Service on the U.S. Department of Agriculture website, as well as in a peer reviewed Journal of Arboriculture. This study is consistent with existing literature on this topic, as a well maintained urban greenspace has shown in multiple studies to deter crime and create safer neighborhood.

Zhang, Y., Zhang, D., & Schelhas, J. (2005). Small-scale non-industrial private forest ownership in the United States: Rationale and implications for forest management. Silva Fennica, Vol. 39(3): 443-454. Retrieved from https://www.fs.usda.gov/treesearch/pubs/25014

Non-industrial private forests (NIPF) ownerships are increasing in the United States. They go out to point out multiple reasons for this increase. These points include a very large amount of U.S. forestland is no longer used for primary timber production, but instead, it's used for non-timber forest products and other environmental services and others. I believe this study to be credible

because it is published on the Forest Service on the U.S. Department of Agriculture official government website. It was also published in a peer-reviewed scientific journal. This study adds to my previous knowledge of privatized forest. Up till this point, I had never thought of the reasons for privatized forests.

Further Fails, Risks, Trade Offs, & Solutions

Skoff-Turner, Jessica., Cavendar, Nicole. (2019). The benefits of trees for livable and sustainable communities. Plants, People, Planet. *New Phytologist Foundation 1(4): 323-335 The benefits of trees for livable and sustainable communities - Turner-Skoff - 2019 - PLANTS, PEOPLE, PLANET - Wiley Online Library*

The Scientific and social benefits of Trees are numerous but so are their potential problems. A sustainable Greenspace has been linked to environmental benefits such as reducing pollution, and an improvement in persons' physical and mental wellbeing. Not to mention, a reduction in crime and improvements in student performance. However, Trees can cause massive property damage and can cause messiness in urban settings. Financial strains due to tree maintenance can also become a problem, especially in the urban setting where tree stress may occur because of the lack of sustainability in the city. A commonly cited disservice associated with trees is the production of biogenic Volatile Organic Compounds which can react with nitrogen oxides, to increase air pollution. The paper is informative in giving the benefits of trees and their potential disservices. Holistically, trees provide more benefits than problems; however, disservices should be taken into account when discussing associated challenges with trees and in local policymaking.

Widney, S., Fischer, B., & Vogt, J. (2016). Tree mortality undercuts the ability of tree-planting programs to provide benefits: Results of a three-city study. Forests, 7(3): 65. https://doi.org/10.3390/f7030065

Tree survival is imperative when discussing the continued benefits that an Urban Forest can provide. Using applications like i-Tree and evaluating tree inventories can help evaluate the integrity of the Urban Forest. The authors of the study give much insight into managing an Urban forest. Despite Urban centers taking initiatives to plant more trees; only a few reach maturity due to the lack of follow-up care. A sustainability plan for existing trees can be more beneficial for prolonged benefits from the Urban forests than simply growing more trees. Trees are a long investment and can be costly if not maintained right. Although, a possible solution to this problem is to focus more on community-driven tree planting programs. Perhaps a sense of ownership and social consciousness, and educational purposes can garner more volunteer work for tree maintenance. It would be insightful to see the limitations of a possible community-driven effort in planting and sustaining tree life.

Cooperation, Initiatives & Coordination

Public/Private Partnerships

Downtown Denver Partnership. Urban Forest Initiative. https://www.downtowndenver.com/initiatives-and-planning/downtown-denver-urban-forest-initiative/

An Urban Forest initiative in Downtown Denver that aims to reimagine how trees are planted and cared for in the Urban Space. Trees were planted in bad sites with little support and small areas with not enough management and this initiative aims to fix those problems. Many

partnerships like the one in Denver, Colorado are happening all over the U.S. with the public sector and private sector. This does help enhance the community aspect of Urban Forestry and provides funding and maintenance when needed. Furthermore, the interesting aspect of this article is the statistics that it list. A twelve percent decrease in crime with an enhanced tree canopy, ten percent added to property added with healthy, mature trees, and an eleven percent decrease in child obesity when compared to spaces with limited access to green spaces. Such benefits should be considered for potential public and private collaborations since this initiative not only leads to healthier cared trees but a better and healthier society.

City of Lincoln Nebraska. (2021). *2021 - 2027 Climate Action Plan* (Verdis Group, Ed.) Lincoln.ne.gov; City of Lincoln, Nebraska. https://www.lincoln.ne.gov/files/sharedassets/public/projects-programs-amp-initiatives/resilient-lincoln/documents/climateactionplan.pdf

Lincoln Electric System's board voted to adopt a 100% net decarbonization goal by 2040. "For more than a decade, the Lincoln Electric System (LES) has demonstrated its commitment to protecting the environment and its commitment to continuous improvement by reducing its fossil fuel usage, helping customers improve energy efficiency, and offering a range of sustainable programs."

A Green Promise

Safford, H.; Larry, E.; McPherson, E.G.; Nowak, D.J.; Westphal, L.M. (2013). Urban Forests and Climate Change. U.S. Department of Agriculture, Forest Service, Climate Change Resource Center. www.fs.usda.gov/ccrc/topics/urban-forests

An overview of the effects of Climate Change on Urban settings and Urban Forest with possible adaptations to changing climate and weather. It is well documented the capture and storing ability of atmospheric carbon dioxide that trees utilized in photosynthesis but trees do also have energy-saving benefits. Interestingly, planting 100 million mature trees around residences in the United States would save around 2 billion annually in reduced energy costs despite only offsetting less than 1% of the United States emissions over a 50-year period. The authors provide an insightful overview of community stewardship and the benefits of migration strategies and energy-saving strategies. Climate change is an important aspect to consider in an Urban setting. An urban setting provides many disadvantages to trees when compared to a forest. This problem can be compounded even more with changing climate and weather. Despite this, the energy-saving benefits are good, and increased community resilience can possibly aid in changing the climate.

Prebble, S., McLean, J., Houston, D. (2021). Smart urban forests: An overview of more-than-human and more-than-real urban forest management in Australian cities. ScienceDirect. Digital Geography and Society. https://doi.org/10.1016/j.diggeo.2021.100013.

When discussing the future, the role of digital technology will become even more prevalent and vital for the sustainability of the Urban forest and thus its numerous benefits. Applications like “i-Tree” and “i-Tree Canopy”, are becoming more reliable as more governments and organizations use the service to value and communicate the concept of the ecosystem services that Trees provide. Furthermore, the expansion of knowledge can also help local communities have an educated perspective on their local Urban Forest. An interesting article that discusses the role of technology and its possible future use when concerning the integrity and value of the Urban Forest. An important emerging topic for discussion on how we can better use technology

to improve the nature around us. Perhaps in the future, we can have the answer on how to deal with different species exclusive diseases and pests or have better monitoring and sustainability equipment. Data Gathering and communication are also worth considering to help strengthen communities.

Wildland-Urban Interface

Lincoln, Nebraska Master Street Tree Plan; Director Defined. Chapter 12.20.020 Trees and Shrubbery (2022)

"The Director shall prepare and maintain a 'Master Street Tree Plan' for the city, showing thereon the genus, species, and variety of trees which may hereafter be planted in or upon any street, parkway, sidewalk space, or other public way within the city, and all such tree planting shall conform to such plan. A current copy of such plan shall be made available for inspection by the public at the office of the Director." Looking ahead, sixty percent of the population will live in urban areas as soon as 2030. With the coast currently being threatened by sea levels rising due to climate change, Lincoln may be one of those inland areas that will be populated by those that have moved, especially if adaptation in those areas becomes impossible. Sea levels rising is not primarily a coastal issue as some of the research is focused solely on. It is worth mentioning that even Lincoln may eventually be impacted by rapid urbanization and changing demographics, therefore changing the community. Not to mention that Nebraska already resettled the most refugees per capita in 2016 according to a Pew Research Center analysis of data from the U.S. State Department's Refugee Processing Center and U.S. Census Bureau.

Nebraska Forest Service (n.d.) *Windbreaks | Nebraska Forest Service*. Nfs.unl.edu. Retrieved April 28, 2022, from https://nfs.unl.edu/publication-type/windbreaks

Windbreak trees become relevant for protecting crops from the hefty gusts of the windswept plains. It is a way of utilizing hills that cannot be planted out with crops. Trees as windbreaks would also provide habitat for wildlife in areas that may be monocultured with crops like corn, or low to the ground soy.

Audubon Bird Protection Society. (n.d.) Bird-Friendly Communities: Why Native Plants Matter. Audubon.org. Retrieved from https://www.audubon.org/content/why-native-plants-matter

"For example, research by the entomologist Doug Tallamy has shown that native oak trees support over 500 species of caterpillars whereas ginkgo, a commonly planted landscape tree from Asia, hosts only 5 species of caterpillars. When it takes over 6,000 caterpillars to raise one brood of chickadees, that is a significant difference."

Naderi, J. R., Kweon, B. S., & Maghelal, P. (2008). "The Street Tree Effect and Driver Safety." ITE Journal, February, 69-73.

The Street Tree Effect and Driver Safety study by Naderi et al illustrated that "tree lined streets were perceived to be safer in both urban and suburban conditions. Individual driving speeds were significantly reduced in the suburban setting with trees." This is relevant for trees and their intersection with mixed use cities. When multimodal transportation is implemented for better mixed use, some pedestrians and bikers don't feel safe with the close presence of speedy cars. Trees can be a barrier between cars and non-car pathways, since the solution of widening streets as a barrier actually just makes cars feel they can go faster. Large trees can even shield against collisions if a car goes off road towards the bike path that runs parallel. By way of example, take the bike path running along N st in downtown Lincoln. Bald Cypress trees have been planted on the mound there between the bike path and the street, and although they are small trees now,

Bald Cypresses have limbs that reach straight out so it grows like a ladder, and these limbs can grow as low on the trunk as the ground. This wide and large tree will be perfect as a barricade between bikers and cars when they are more mature. If Lincoln expands their bike paths, this N st tree model should be used so that tree presence is also expanded simultaneously

Migratory Bird Treaty Act of 1918 | U.S. Fish & Wildlife Service. (1918) Www.fws.gov. https://www.fws.gov/law/migratory-bird-treaty-act-1918#:~:text=The%20Migratory%20Bird%20Treaty%20Act%20(MBTA)%20prohibits%20the%20take%20(

A good arborist is prepared to deal with wildlife encounters. One of the benefits of trees is added wildlife habitat, so it is important that this is upheld when humans become involved in trees. An arborist caring for a tree may encounter bats or even ducks taking up residency, so they should know how to deal with them accordingly, and this would usually involve calling the appropriate migrating bird or bat expert. Making sure there are no animals, birds, or baby animals in nests on branches or trees that are being removed should also be the standard. Migratory Bird Act as well.

Lundak, M. (2021, December 26). Boy Scout troop collecting, recycling Christmas trees, helping feed Omaha Zoo animals. Https://Www.wowt.com. Retrieved April 28, 2022, from https://www.wowt.com/2021/12/27/boy-scout-troop-collecting-recycling-christmas-trees-helping-feed-omaha-zoo-animals/

Christmas trees, Elm trees, Ash, and Birch scraps that are not diseased can be dropped off at the Henry Doorley Zoo in Omaha, Nebraska. Animals are enriched by this recycling, as they enjoy peeling the bark off the brush.

Nikiforuk, A. (2018, October 22). Tree Teachings: How Forests and Wildfires Are Critically Linked. The Tyee. https://thetyee.ca/News/2018/10/22/Tree-Teachings-Forest-Wildfires/#:~:text=Diana%20Beresford%2DKroeger%20and%20Katsuhiko

"Years ago, a brilliant Japanese marine chemist Katsuhiko Matsunaga decided to see if there was any scientific truth behind an old Japanese adage: 'If you want to catch a fish, plant a tree.' Matsunaga discovered a fascinating chemical tale behind the ancestral lore, says Beresford-Kroeger. Decomposing leaves are full of fulvic acid, just one of many humic acids that enrich the soil. The compound is capable of binding with iron in the soil, explains the botanist."

"'The earth is rich in iron, but the oceans are poor,' she adds. Decomposing leaves in forested watersheds help to flush iron into the ocean, where it acts as a catalyst for the building of phytoplankton. Without a supply of oxygenated iron, phytoplankton can't perform photosynthesis and make the rich food that all marine life depends on. Great wildfires and logging reduce the leaf litter and therefore the amount of iron that flushes into the ocean, which, in turn, reduces the plankton." This impacts urban port cities and other coastal cities. This point also brings us back to economics and money issues discussed in the beginning of this document.

Wohlleben, P. (2022). The Secret Wisdom of Nature: Trees, Animals, and the Extraordinary Balance of All Living Things... Stories from Science and Observation. Greystone Books.

Related to the previous annotation, Peter Wohlleben also points out that lack of fish could also impact other riparian corridors and river towns, as Salmon travel up streams and their decomposition adds necessary nutrients to soils and brings in the biodiversity that comes to feed on that. Another example of wildlife in regard to wolves is also brought up by Wohlleben. If people living near Yellowstone want to kill wolves, that can cause an increase in Elk. Those Elk

then eat all the young growth that emerges, preventing anything from growing. Supplementary hunting is not a solution to this.

Akbari, Hashem. (2002) "Shade trees reduce building energy use and CO2 emissions from power plants." Environmental pollution 116 S119-S126.

American Arborists (2018, February 18). *Three Jobs Surprisingly Less Dangerous Than an Arborist.* From https://www.americanarborists.net/tree-tips/2018/february/three-jobs-surprisingly-less-dangerous-than-an-a/

Anderson, Linda M., and H. Ken Cordell. (1988) "Influence of trees on residential property values in Athens, Georgia (USA): A survey based on actual sales prices." Landscape and urban planning 15.1-2, 153-164.

The Arbor Day Foundation. (2022). History at arborday.org. www.arborday.org. From https://www.arborday.org/celebrate/history.cfm

Audubon Bird Protection Society. (n.d.) Bird-Friendly Communities: Why Native Plants Matter. Audubon.org. Retrieved from https://www.audubon.org/content/why-native-plants-matter

Beals, H.O.; Davis, T.C. (1977, January) Figure in wood - an illustrated review. *Alabama Agricultural Experiment Station, Auburn University: Auburn Alabama*, Bulletin No. 486, 15-16

City of Lincoln Nebraska. (2021). *2021 - 2027 Climate Action Plan* (Verdis Group, Ed.) [Review of *2021 - 2027 Climate Action Plan*]. Lincoln.ne.gov; City of Lincoln, Nebraska. https://www.lincoln.ne.gov/files/sharedassets/public/projects-programs-amp-initiatives/resilient-lincoln/documents/climateactionplan.pdf

Cowett, F. D., & Bassuk, N. (2017). Street Tree Diversity in Three Northeastern U.S. States. Arboriculture & Urban Forestry, 43(1). https://doi.org/10.48044/jauf.2017.001

Davey Resource Group. (2017). Urban Forest Resource Analysis The State of Montana. http://dnrc.mt.gov/divisions/forestry/docs/assistance/urban/docs-urban-fact-sheets/montana-urban-forest-resource-analysis-2017.pdf

Dilley, J., Wolf, Kathleen L. (2013). Homeowner Interactions with Residential Trees in Urban Areas: International Society of Arboriculture. *Arboriculture & Urban Forestry 39(6): 267-277* .pnw_2013_dilley001.pdf (fs.fed.us)

Donovan, Geoffrey H. (2017). Including public-health benefits of trees in urban-forestry decision making: Urban Forestry & Urban Greening. Elsevier 22:120-123 https://www.sciencedirect.com/science/article/abs/pii/S1618866716303909

Downtown Denver Partnership. Urban Forest Initiative. https://www.downtowndenver.com/initiatives-and-planning/downtown-denver-urban-forest-initiative/

Dunn, Connor (2015). *Latitude opens its doors to students as construction continues*. JournalStar.com. Retrieved April 28, 2022, from https://journalstar.com/news/latitude-opens-its-doors-to-students-as-construction-continues/article_261d475c-b01f-5efb-bf96-d6eef1048395.html

Hauer, M. E., Evans, J. M. & Mishra, D. R. (2016) Millions projected to be at risk from sea-level rise in the continental United States. Nat. Clim. Change 6, 691–695.

International Society of Arboriculture. (n.d.). International Tree Climbing Championship Aerial Rescue Event. Retrieved April 28, 2022, from https://www.itcc-isa.com/Portals/0/docs/about_Eventdescriptions_AerialRescue.pdf

Jim, C. Y., Konijnendijk van den Bosch, C., & Chen, W. Y. (2018). Acute Challenges and Solutions for Urban Forestry in Compact and Densifying Cities. Journal of Urban Planning and Development, Vol. 144(3). Retrieved from https://ascelibrary.org/doi/full/10.1061/%28ASCE%29UP.1943-5444.0000466?casa_token=UN7zSuS4pMQAAAAA%3AzYl0FkwmTw6nWzIFeaU1AqN0XZN1qHuZQ0iAeWzstzP6Nj595RhLoI2CKU3VKkmMbwap1_WgQLTd

Johnston, Devan. Pegasus Tree Service, *Certified and Insured Arborist in Lincoln, NE.* Personal communication and photos. (November 13, 2021)

Kellogg, W., Mikelbank, B., Laverne, R., & Hexter, K. (2017). The Economic Value of Tree Preservation in a Weak Land Development Market Region. Arboriculture & Urban Forestry, 43(2). https://doi.org/10.48044/jauf.2017.006

Kuo, F. E. (2003). Social Aspects of Urban Forestry: the Role of Arboriculture in a Healthy Social Ecology. Journal of Arboriculture, Vol. 29(3):148-155. Retrieved from https://www.nrs.fs.fed.us/pubs/3860

Lincoln, Nebraska Master Street Tree Plan; Director Defined. Chapter 12.20.020 TREES AND SHRUBBERY (2022)

Lincoln, Nebraska Master Street Tree Plan; 12.20.050 Issuance of Permit; Requirements Pertaining to Planting, Maintaining, Removal, and Destruction. (2022)

Lincoln Parks & Recreation. (n.d.). Arborist Examination Study Guide

Lincoln Parks & Recreation. Community Forestry: Adopt-an-Ash Program. (n.d.). www.lincoln.ne.gov. Retrieved April 28, 2022, from

https://www.lincoln.ne.gov/City/Departments/Parks-and-Recreation/Community-Forestry#section-4

Lundak, M. (2021, December 26). Boy Scout troop collecting, recycling Christmas trees, helping feed Omaha Zoo animals. Https://Www.wowt.com. Retrieved April 28, 2022, from https://www.wowt.com/2021/12/27/boy-scout-troop-collecting-recycling-christmas-trees-helping-feed-omaha-zoo-animals/

Messimer, J., Maynard, S., & Loveless, G. (2020, December 11). The Happiest People in America Live in This City. Men's Health. https://www.menshealth.com/health/a34919033/happiest-cities-in-america/

Migratory Bird Treaty Act of 1918 | U.S. Fish & Wildlife Service. (1918) Www.fws.gov. https://www.fws.gov/law/migratory-bird-treaty-act-1918#:~:text=The%20Migratory%20Bird%20Treaty%20Act%20(MBTA)%20prohibits%20the%20take%20(

Miller, R. W., Hauer, R. J., & Werner, L. P. (2015). Urban Forestry: Planning and Managing Urban Greenspaces. (3rd ed.) Waveland Press, Inc.

Naderi, J. R., Kweon, B. S., & Maghelal, P. (2008). "The Street Tree Effect and Driver Safety." ITE Journal, February, 69-73.

Near South Neighborhood Association. (2022) *"The Near South*." Retrieved April 28, 2022, from https://nearsouth.org

Nebraska Forest Service. (2019, August 19) *Top 10 Tree Planting Mistakes | Nebraska Forest Service*. Nfs.unl.edu. Retrieved April 28, 2022, from https://nfs.unl.edu/publications/top-10-tree-planting-mistakes

Nebraska Forest Service (n.d.) *Windbreaks | Nebraska Forest Service*. Nfs.unl.edu. Retrieved April 28, 2022, from https://nfs.unl.edu/publication-type/windbreaks

Nikiforuk, A. (2018, October 22). Tree Teachings: How Forests and Wildfires Are Critically Linked. The Tyee. https://thetyee.ca/News/2018/10/22/Tree-Teachings-Forest-Wildfires/#:~:text=Diana%20Beresford%2DKroeger%20and%20Katsuhiko

North, E., & Students (2019, April). *Master Street Tree Plan Lincoln, Nebraska*. Retrieved April 28, 2022, from http://www.treehusker.com/uploads/1/1/6/7/116727675/masterstreettreeplan-april2019.pdf

NPR. (2021, July 8). *What The Rise and Fall of Lumber Prices Tell Us About the Pandemic Economy*. NPR.org. https://www.npr.org/2021/07/08/1013819703/what-the-rise-and-fall-of-lumber-prices-tell-us-about-the-pandemic-economy

NYC Parks. (n.d.). *Illegal Tree Work and Damage: NYC Parks*. www.nycgovparks.org. Retrieved April 28, 2022, from https://www.nycgovparks.org/services/forestry/illegal-tree-work#:~:text=Removing%20a%20tree%20without%20a

Pegasus Tree Service, *Certified and Insured Arborist in Lincoln, NE.* Personal communication and photos (November 13, 2021)

Pew Research Organization. (2016, December 02) Nebraska, North Dakota, Idaho took in most refugees per capita in fiscal 2016 . Retrieved February 5, 2019, from http://www.pewresearch.org/fact-tank/2016/12/06/just-10-states-resettled-more-than-half-of-recent-refugees-to-u-s/ft_16-12-02_usrefugees_percapita/

Prebble, S., McLean, J., Houston, D. (2021). Smart urban forests: An overview of more-than-human and more-than-real urban forest management in Australian cities. ScienceDirect. Digital Geography and Society. https://doi.org/10.1016/j.diggeo.2021.100013.

Safford, H.; Larry, E.; McPherson, E.G.; Nowak, D.J.; Westphal, L.M. (2013). Urban Forests and Climate Change. U.S. Department of Agriculture, Forest Service, Climate Change Resource Center. www.fs.usda.gov/ccrc/topics/urban-forests

Seitz, Jennifer, and Francisco Escobedo. (2008) "Urban forests in Florida: Trees control stormwater runoff and improve water quality." EDIS 2008.5

Skoff-Turner, Jessica., Cavendar, Nicole. (2019). The benefits of trees for livable and sustainable communities. Plants, People, Planet. *New Phytologist Foundation 1(4): 323-335* *The benefits of trees for livable and sustainable communities - Turner-Skoff - 2019 - PLANTS, PEOPLE, PLANET - Wiley Online Library*

Sohn, W., Kim, H. W., Kim, J.-H., & Li, M.-H. (2020). The capitalized amenity of green infrastructure in single-family housing values: An application of the spatial hedonic pricing method. Urban Forestry and Urban Greening, Vol. 49. Retrieved from https://doi.org/10.1016/j.ufug.2020.126643

The Nature Conservancy. (2019, December 2) Real vs Fake Christmas Tree. Www.nature.org. https://www.nature.org/en-us/what-we-do/our-priorities/protect-water-and-land/land-and-water-stories/real-vs-fake-christmas-tree/

The Near South. (n.d.). Near South Neighborhood Association. Retrieved April 28, 2022, from https://nearsouth.org

The Tree Care Industry Association. (n.d.). Guidance for Crane Practices in Arboriculture. Retrieved April 28, 2022, from https://www.tcia.org/TCIAPdfs/Resources/Arboriculture/Technical/guidance-for-crane-practices-in-arboriculture-20120601.pdf

Tree Equity Score. (2022). American Forests. Retrieved April 28, 2022, from https://www.americanforests.org/tools-research-reports-and-guides/tree-equity-score/

Trees for Energy. (n.d.). *What is the difference between arboriculture and urban forestry? – Trees for Energy Conservation*. Trees-Energy-Conservation.extension.org. Retrieved April 28, 2022, from https://trees-energy-conservation.extension.org/what-is-the-difference-between-arboriculture-an

TreeStuff. *Tree-o-Cache*. (n.d.). www.treestuff.com. Retrieved April 28, 2022, from https://www.treestuff.com/tree-o-cache

University of Nebraska - Lincoln. (2020, February 17) *Calling all Tree Huskers: New forestry major approved*. News.unl.edu. Retrieved April 28, 2022, from https://news.unl.edu/newsrooms/today/article/calling-all-tree-huskers-new-forestry-major-approved/#:~:text=With%20the%20unanimous%20vote%20by

University of Nebraska Lincoln. (2021). Study: Trees have a $31.5 billion impact on home values each year. Nebraska Today. https://news.unl.edu/newsrooms/today/article/study-trees-have-315-billion-impact-on-home-values-each-year/

Westphal, Lynne M. (2003). Social Aspects of Urban Forestry: Urban Greening and Social Benefits: Study of Empowerment Outcomes. *Journal of Arboriculture 29(3):*137-147 https://www.fs.usda.gov/treesearch/pubs/14148

Widney, S., Fischer, B., & Vogt, J. (2016). Tree mortality undercuts the ability of tree-planting programs to provide benefits: Results of a three-city study. Forests, 7(3): 65. https://doi.org/10.3390/f7030065

Wohlleben, P. (2022). The Secret Wisdom of Nature: Trees, Animals, and the Extraordinary Balance of All Living Things... Stories from Science and Observation. Greystone Books.

Xu, QF., Jiang, PK., Wu, JS. et al. (2015.) Bamboo invasion of native broadleaf forest modified soil microbial communities and diversity. Biol Invasions 17, 433–444. https://doi.org/10.1007/s10530-014-0741-y

Zhang, Y., Zhang, D., & Schelhas, J. (2005). Small-scale non-industrial private forest ownership in the United States: Rationale and implications for forest management. Silva Fennica, Vol. 39(3): 443-454. Retrieved from https://www.fs.usda.gov/treesearch/pubs/25014